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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

27TH ANNUAL MEETING AT ST. LOUIS, MO.

On Wednesday, August 21st, this distinguished body of American scientists met in the chapel of the University of St. Louis, at 10 A. M. Prof. Simon Newcomb, late President, opened the exercises by introducing Prof. O. C. Marsh, of New Haven, the newly elected President, who assumed the position with a few appropriate remarks. Professor H. C. Bolton, General Secretary, (to whom and to the *Globe-Democrat* we are indebted for the material for this report) and Professor F. W. Putnam, Permanent Secretary, occupied their proper places and announced the order of exercises and the arrangements made by the proper committees.

After addresses of welcome by the Mayor of St. Louis and Professor W. T. Harris, of the St. Louis Academy of Science, which were responded to by President Marsh, the regular business of the Association was commenced.

The Secretary read the following list of members deceased since the date of the last meeting: Abram Sager, of the University of Michigan; Ezra Read, of Terre Haute, Indiana; Joseph Henry, of Washington D. C., who was an original member of the Association, and President of the second meeting, held in Cambridge, Mass. in 1849, and had always taken an active interest in the Association; C F. Hartt, of Cornell University; James Swain, of Fort Dodge, Iowa; G. W. Keely, of Waterville, Me:, died in 1878, an original member of the Association; John V. L. Pruyn, of Albany, N. Y., an original member of the Asso-

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ciation; James Bowron, of South Pittsburg, Tenn.; Wm. Monroe, of Concord, Mass.; John W. Armstrong, D. D., of Fredonia, N. Y.; Ebenezer S. Snell, of Amherst, Mass., died in 1877, who joined the Association at its second meeting; F. W. Bardwell, Professor of Astronomy in the University of Kansas, Lawrence, Kansas.

The following named gentlemen were elected members of the Standing Committee: A. G. Weatherby, C. V. Riley, F. W. Clarke, George Engelman, J. W. Osborne and A. H. Worthen.

Messrs. R. H. Ward, Simon Newcomb and H. C. Bolton were elected members of the Committee of Section A—Mathematics, Astronomy, Physics, Chemistry and Mineralogy.

Messrs. Morgan, Safford and Latimore were elected members of the Sectional Committee of Section B—Geology, Zoology, Botany and Anthropology.

The Entomological Section, which commenced its sessions the day before and listened to several interesting papers by Miss Emily Smith, of Peoria, Ill., and Prof. Riley, of this State, held an afternoon session at the Lindell Hotel, at which Dr. J. Lintner, President, of Albany, N. Y., discoursed briefly on the methods of collecting *Lepidoptera*.

Miss Emily Smith spoke on the natural history of *Argyrolepia quercifoliana L.*, an insect whose larva in 1877 devastated the oak forests of Wisconsin and Illinois, leaving the trees bare of leaves as if winter had come.

A very interesting discussion came up on the question of instinct (or reason?) displayed by some insects. Miss Smith cited the case of *Pimpla conquisitor*, a parasite on bark lice, that deposits its egg in the ova-producing females only—a curious case of instinctive selection. Mr. Wetherby cited a case of instinct at fault displayed by the larva of *Platysamia cecropia*, confined in a glass, and President Lintner spoke of a *Prometheus* larva that lashed two twigs together in order that it might not be prevented by the breeze from spinning its cocoon.

There was a little informal discussion as to the visual powers of spiders, and then the Section adjourned until the next annual meeting.

The evening session was held as before, in the chapel of the University, and the first paper read was entitled

THE PHILOSOPHIC METHOD OF THE ADVANCEMENT OF SCIENCE.

BY PROF. R. H. THURSTON, HOBOKEN, N. J.

LADIES AND GENTLEMEN: I have chosen for my subject on this occasion one which is, in my opinion, peculiarly suited for the annual address of a Vice President of the American Association for the advancement of Science—a subject which may appear a novel one to many among those to whom it is presented, but one which will, I hope, prove none the less interesting for that fact. I propose to indicate the existence of a "Science of the Advancement of Science," exhibiting some of the facts upon which it is based, enunciating some of the laws and the principles of that science, and thus, as well as I may, presenting its philosophy.

I propose to show, as concisely as possible, where and when this philosophy had its origin and what has been its method of growth. I desire to show what should to-day be done for this science, to indicate what seem to me the best methods, and what system is likely most effectively to facilitate its progress.

Science—which has been defined by Fleming as "knowledge, certain and evident in itself, or by the principles from which it is deduced or with which it is certainly connected"—consists of two parts. As Sir William Hamilton has stated it, science is a "complement of cognitions, having in point of form the character of logical perfection, and in point of matter the character of real truth." While it is the foundation of all art, it is itself founded upon a precise and sure knowledge of certain of the great facts of nature and upon man's power of detecting and of revealing the great truths which have been established by the Creator of the universe. The two parts are the pearls of truth which man has thus been able to gather and the chain of laws and principles upon which those facts are strung and by which they are firmly connected as the pearls of a lady's necklace are bound together by the silver thread or the golden wire which gives the precious treasure its continuity. The basis of all science is the mass of facts which make up the universe of the known and the to-be-known, and its existence depends upon and is assured by the immutability of the laws of nature and of all those principles of philosophy which are woven into the connecting chain.

The man of science, the philosopher, whose task it is to create and to advance human knowledge of the great kingdom of nature, is, therefore, a discoverer of facts, an observer of phenomena, a student of the laws of nature and a codifier of those laws, as well as a systematic recorder of facts. He gathers the pearls of truth and collects the silken threads that we term principles, spins them into the cords, works them into the chains upon which he strings his pearls, and thus a science is formed. Thus, centuries before the commencement of the Christian era the Chaldean astrologers were studying the motions of the sun, the planets and the stars, and recording their observations for the benefit of those who, in modern times, have been glad to fit those facts to lately discovered law; thus, Kepler, month after month and year after year, assuming one mathematical law after another to be applicable to the relation of periodic times to the distances of the circling planets from their central sun, tried to fit already discovered pearls of fact to his various threads of principles, and, after nineteen years of persevering labor, found the right string at last, and proclaimed the great law which Newton then fitted to other facts, and, taking another great step, this greater philosopher showed to all men the world-wide prevalence of the law of gravitation. Thus, again, those great astronomers and mathematicians, Leverrier and Adams, seizing upon the great fact of the indefinite application of Newton's law of gravitation, proved the other till then unknown fact of the existence of a mighty world, far beyond the then recognized boundary of the solar system, and told observers just where to point their telescopes to bring the previously unseen planet into view.

But, although scientific work has been in progress during so many centuries, it was only in the time of Galileo, and when, two centuries ago, his contemporary,

"Bacon, at last a mighty man, arose,
Whom a wise King and nation chose
Lord Chancellor to both their laws,"

and when the experimental philosophy of the first and the system of inductive philosophy of the second united to form a perfect whole—it was only then tha the existing system of philosophy had a beginning.

The peripatetic philosopher had, two thousand years before, adopted the so-called modern system in his teachings. Aristotle may, therefore, be with greater propriety called the father of that inductive philosophy of which Bacon was the first modern expounder, and of which Galileo was the first of modern disciples—the first of systematic experimentalists. It was only after this system of true philosophy had become accepted by learned men that it became possible for the various branches of modern science to take shape. It was only then that the discoveries of Galvani, the inventions of Volta and of Von Guericke, and the facts recorded by Gilbert, the investigations of Oersted and of Franklin, and the researches of the multitude of their illustrious successors in the present generation, could give form to the now well-developed department of electrical science, It was only after this time that the application of quantitative methods of analysis by Lavoisier, the greatest of chemists, could enable his confreres and his successors to combine the facts recited by the alchemists of earlier times, the discoveries of Priestly and Scheele and of Cavendish and of the later chemists, with the laws enunciated by Boyle and Dalton and Avogadro and others, could only then contrive to form a system of chemical philosophy, which, still avowedly crude, is nevertheless one of the most magnificent of all physical sciences. It was only after the inductive method had become recognized as the only effective method of acquiring a knowledge of the phenomena and the laws of nature, that mathematical sciences—originating as they did in an unknown antiquity, and given form by Euclid and Diophantus, by the Romans, the Greeks and the Arabians centuries ago, and perfected in later times by Descartes, Newton and Leibnitz—became applicable to the investigations by the natural philosophers in every branch of their magnificent work.

The richest fruits of this great system are familiar to all, and have nearly all been developed within the memory of many to whom these words are addressed. The facts revealed by the researches of Rumford, Davy and Joule have been grouped and systematically united by the laws revealed by Rankine, Thompson, Clausius and other hardly less eminent men, and the science of thermodynamics which has been thus created has been applied and put to the proof by Hirn and a hundred other distinguished engineers of our own time. Finally, it is only now that it is evident that this last is but another branch of the universal science of energetics which controls all effective forces in all departments of science. The man is still to come forward who is to combine all facts comprehended by this latest science into one consistent whole, and to illustrate its application in all methods of exhibition of kinetic energy.

The grand principle which we are just beginning to admit and recognize as

underlying every branch of knowledge and as forming the foundation of all the sciences—of all science—seems, when stated, to be simply an axiom. The Scriptural declaration that the universe shall endure forever is but a statement of the principle which is now becoming more and more generally admitted as a scientific truth, viz: That the two products of creation, matter and force and the fruit of their union—energy—are indestructible.

The grand underlying basis of all science is found, then, in this principle: All that has been created by Infinite power—matter and its attribute, force, and all energy—is indestructible by finite power, and shall continue to exist as long as the hand of the Creator is withheld from their destruction. This law has been admitted almost from the time of Lavoisier, so far as it affects matter; it has been admitted as applicable to energy since the doctrines of the correlation of forces and the persistence of energy became acknowledged by men of science, and we are gradually and rapidly progressing toward the scientific establishment of the law of persistence of all existence, whether of matter, force and energy or of organic vitality, and perhaps even of soul-life. The truths of science are thus coming into evident accord with those doctrines of religious belief which underlie every creed. We are, however, apparently as far as ever from the determination of the question whether the higher forms of force and energy have quantivalent relations and intertransformability, notwithstanding the fact that a belief in the identity of mind and matter and that in matter can be discerned "the promise and potency of all terrestrial life" has been avowed, explicitly or implicitly by more than one great thinker, who has wandered into the realms of speculation.

Looking back to the beginning, we see, then, that in the beginning there entered upon an existence which is of indefinite duration a great universe of matter endowed with its characteristic attributes—the forces of nature. These forces acting upon all matter gave birth to a fixed amount of actual energy, and are capable of producing another fixed quantity of what is now potential energy. Energy thus coming into existence remains constant in amount as the quantity of created matter remains constant.

The action of these forces upon this matter has given rise to every phenomenon which has come or does now come within the range of scientific inquiry. But all known forces are seen at once to be capable of classification, according to their methods of affecting matter, into three great classes:

(1.) These forces with which we are able to make ourselves so thoroughly familiar that we find no difficulty in assigning to each of them its proper place in the scheme of scientific systemization, and which we have found it comparatively easy to distinguish by their peculiar and readily observed effects. These comprehend the familiar physical forces, as gravitation, electricity, chemical affiinity and mechanical forces.

(2.) The vital forces—those which are necessary to the preservation of all life, which produce and promote the growth of all organisms having life, and which are less readily comprehended, more difficult of study, and far less subject to the modifying power of man than are those of the first-named class.

(3.) The forces of the soul and of the intellect—those most wonderful and mysterious of all known forms of force; forces of the nature of which we know nothing, and of the effects of which, actual and possible, we have the least comprehension.

(4.) That great master-force, Omnipotence, which is the source and sustainer of all forces and of all existences.

By the study of the universe as it now exists, philosophers are led to perceive that its present state is such as it would have been had these various forms of matter with which we are surrounded, and of which we are ourselves corporeally composed, and other existences which we suspect to form a part of our universe, seen at the beginning, so distributed by the Creator and so placed in reference to the several kinds of forces that the former, acted freely upon by the latter, should take all the infinite variety of shape and all that inconceivable variety of growth that has by the wonderful process called evolution been brought into the history of the universe; and they are still continuing to illustrate the mighty and incomprehensible power of Him who is the Author of all things. It is seen that, under the action of these forces upon this matter, a universe is forming out of chaos, that all its parts are exhibiting the wondrous power and the marvelous intricacy of His scheme, and the yet more wonderful simplicity of the means by which He is accomplishing His purposes.

Studying the universe as far as we may in detail, we see that each of the various forms of force which has been set at work to modify the position and the character of matter has a special part to perform, and that the first class has a sphere of operation which is fully within the reach of our senses; that the second class of forces is also, to a certain extent, familiar to us through a knowledge of their effects; but that of the last two of the several classes of forces existing in nature we are entirely unprepared to treat. We are too utterly ignorant of them to do more than speculate, and our speculations are not more likely to find any directly profitable result than those of our Greek predecessors in that "unknowable" field. There is no beginning, even in a true moral and intellectual science. We have found no quantitative measures of those forces or of their effects, and no definite principles are known which control their action. They must probably be left for the consideration of those who follow us.

The last named—Omnipotence—is beyond the imagination even, but, studying these forms of the manifestation of force which are divided between the first two classes just mentioned, we at once perceive a distinction which is as well defined as the line of demarcation between the two classes of phenomena to which they give rise.

The physical forces—and I intend here to include the mechanical and chemical as well as the forces which are usually alone treated of in works on physics—are capable of being detected, of being distinguished by certain readily defined qualities and of being accurately determined by quantitative measurement. The conditions which lead to their active exertion are capable of being ascertained, and the precise results of their action under a given set of conditions may be us

ually predicted. These conditions are capable of certain definite modifications by the power of man, and the changes of effect which will result from such changes of condition are predicable. Those effects which nature is accustomed to produce in certain cases by the action of these forces may be modified by man without entirely defeating the force in its effort to produce a given change of mode of existing energy. These forces, acting alone, never give rise to the more intricate forms seen in nature. Their highest product in the whole morphological catalogue is a crystal of more or less perfect shape, but of a form which is always of some simple geometrical class. These forces rarely exhibit the play of definitely directed energy tending to effect a perfectly definite but remote effect. These effects are the accidental and the incidental, so far as the more wonderful and intricate of the operations of nature are concerned.

The vital forces, on the other hand, effect operations which human power cannot touch except to impede and to destroy. They have for their mission the creation of strangely intricate and curiously organized structures in which are stored certain definite amounts of energy, and which are given a power of acquiring and of applying extraneous energy, in probably definite amount, to the accomplishment of certain kinds of tasks. Man may modify their operation and may produce some change in the effects which they are appointed to bring about; but it is only by deranging their action. He can never directly assist them. That store of vital energy which was created in the infinite past and which is now passing into one after another of the new forms of life which are daily, momentarily coming into the field of our cognizance, is developing organisms of every grade from the human form down to that of the simple life-seed, if such exists—the basic protoplasm—and man can only touch to injure or to destroy the beautiful, the wonderful, the incomprehensible creation. As it appears to his wondering mind it is an existence which he can influence only for evil, and an unimaginable enigma which he cannot solve.

Of these two sets of forces, the one is unintelligent as to the direction of its action and indifferent to the results attained by such action, and is governed, under all known conditions, by laws which are as invariable as they are simple. The other class appears to act at all times upon a definite plan, and under the direction of an intelligence which leads to the production of the most elegant and intricate designs and the elaboration of the most wonderful and mysterious of organisms. It is in the structures, which are their work only, that the strange phenomena of life are exhibited to the intelligence which vainly endeavors to comprehend them.

A system which shall be a real science of the advancement of science is thus seen to include :

(1.) Observers, or discoverers and collectors of fact, investigators in the field of research.

(2.) Systematizers of fact and of law—creators of the philosophy of science.

(3.) Teachers of science, expounders of the philosophy and explainers of the phenomena of accepted science.

Each of these classes requires for the proper performance of his work a certain amount of material assistance, and needs both money and apparatus.

Science began her work at a time so remote that her earliest records were made before the historian was competent to preserve them. The Chaldeans had among their astrologers, 3,000 years ago, most accurate observers; for, as Draper tells us in his learned work on the progress of civilization, their estimate of the length of the "Saros" or cycle of eclipses—a period of more than nineteen years—was "within nineteen and one-half minutes of the truth." But until the time of the great Ptolemy, the second of the essentials of the advancement of science, a codifier of its facts and laws, remained a want unsupplied. The East Indians and the Greeks began the study of algebra, geometry and the other simpler sections of mathematical science; but it required a Diophantus and a Euclid to give those departments of science form. Aristotle declared the true principles upon which all progress in science must be based; but it was only when Bacon explained, and when Galileo and Newton illustrated the application of those principles, that the real growth of the existing natural sciences actually became perceivable. It was only then that experimental physical science found practitioners. Previously, all scientific work had been the work of observation.

But why has not the progress of science during the past been all that it might have been? Why is the advancement of science to-day so difficult and irregular and toilsome? Evidently and simply because there has never been created a systematic method adapted to the encouragement of its growth. The right men have never been carefully selected and thoroughly and carefully trained to the work which is most in need of skilled men. Men of science have not always worked in directions which call most urgently for their attention; but have often followed their own unreasoning inclinations into side paths, and they have thus wasted powers which might have given splendid returns for that energy and talent thus expended. The endowment of research has formed no part of a complete scheme for the advancement of science, or, at least, it has never had the attention and the labor given to its procurement that it should have had. The materials and the apparatus placed in the hands of men of science by those to whom they have been compelled to look for material assistance has too generally been insufficient in quantity, and too incomplete in its character to permit the most effective application of their efforts.

For all these reasons and more, we are not to-day, as we have not been in the past, prepared to do all that we should in the advancement of science and of the arts which so greatly depend upon it. Indeed, it is too often the case that the man of science holds himself entirely aloof from the duty, to which every consideration should urge him, of aiding in every way which lies in his power in the advancement of arts by the discovery and invention of methods of application of his knowledge and his philosophy to every one of the industries of common life.

Were he to do this more conscientiously, he would secure to science far more effectually, also, that assistance from the man of the world and from the man of

business upon which he is, despite himself, very greatly dependent. There is certainly no more creditable change than that which we see going on in these latter days, the growing inclination of these two great classes to countenance and to assist each other. Now we come to the practical and vitally important qu stion: What are *we* to do? What methods and what plans are to be initiated and carried out by men of science and the friends of science to secure that advancement of science and the diffusion and application of scientific knowledge most rapidly and uninterruptedly and to obtain a maximum return with the expenditure of a minimum of time and labor. How can we best acquire knowledge of facts, a comprehension of laws, an understanding of their order and relations in nature's code, and, if so much is to be permitted us, how may we hasten that great day when the sciences, now apparently isolated and unconnected, shall be seen to form parts of one magnificent system, each interlinked with others and no one isolated. A system to which all are essential, as the perfect and symmetrical and endless links of chain armor combine to make one complete and infrangible whole?

The method to be adopted is easily stated. It is simple, comprehensive, effective. It secures the maximum efficiency of the individual and it includes the creation and the administration of organizations in which numbers assist by combined effort the acquirement, the diffusion and the useful application of the sciences to the moral, the intellectual and the social advantage of humanity.

The science of the advancement of science dictates that we shall seek:

1. To determine what are the most promising and most important directions of exploration in the great universe of the knowable.

2. That we shall endeavor to find young men fitted by nature and led by their own inclinations to become successful observers, discoverers and philosophers—such men are as rare as are poets. Aid them to gain positions in which their talents may have full scope and assist to make useful the results of their labor.

3. That we make it a part of our work to obtain for these investigators the means of research and the material aid which are necessitated by the rapid and ever accelerating advances of knowledge for which we are indebted to them; to secure the endowment of new schools of science, the more complete organization of older schools, and liberal provision of apparatus and material for every investigator.

4. That we seek to improve our methods of instruction in science, to introduce into our educational systems a better scientific curriculum and far more extended courses, both of pure and of applied science, and to made the position of a teacher of science, viewed from the world's standpoint, a far more desirable one than it has yet become.

5. To make the organization and the operation of our Academies of Science and of our societies for the advancement of science far more thoroughly effective.

6. To endeavor to exhibit to both classes the fact that there exists between

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the man of science and the man of business a community of interest; the fact that he who accumulates wealth is largely indebted for his success to him who is unselfishly revealing to him those secrets of nature, without a knowledge of which he and the world about him would be to day in the lowest state of barbarism; and the fact that, on the other hand, it is only by the possession of such means as only wealth can furnish that the astronomer can study the wonders of the heavens, the chemist can pursue his researches among the mysteries of molecular combination, or the physicist investigate the beautiful and most wonderful phenomena which are illustrated in the discoveries and inventions which are so rapidly now succeeding each other. Men of science and educated men of the world must be brought to know more of each other, and must be held in bonds of closer relationship to secure the maximum of efficiency in our methods of advancing science and of securing to mankind its greatest benefits.

The endowment of schools of science must precede the gathering of the fruits of research; but the endowment of schools must be preceded by the enlightenment of the possessors of wealth, and by the awakening of their interest in scientific work. The American Association for the Advancement of Science has been exceptionally fortunate in securing an appreciation among its members of this community of interests. No existing organization has done more—perhaps none has done as much—to bring together the two classes, the workers in science and the non-professional lovers of science.

When such a system of promoting the advancement of science as I have made a weak effort to describe shall have become familiar to all for whom it has an interest, and when individuals and scientific organizations shall endeavor methodically to work by it, we shall see a new revival of learning—a later intellectual renaissance. Let us hope that we may see this taking place during our own time. Let us hope that a century in which that great investigator, Sir Humphrey Davy, brought out what he claimed to have been his greatest discovery—Michael Faraday—shall see even nobler work done by many later Davys and Faradays; that the century that, in its early years, saw the splendid achievements of men like Young, like Rumford and Cavendish, like Laplace, Lagrange, Fourier, and Carnot, of men like Gauss and Magnus, and like our own recently lost Henry, that this century may yet prove even more prolific of such noble sons.

Let us have faith that an age which still boasts of men like Thompson and Joule, Helmholtz and Kirchhoff, of men like Pierce and the long list of his successors to the presidency of this Association, all of whom have won that distinction by their works; that such an age shall see the science founded by Rankine and his comrades, correlated to the other branches of energetics, shall see the wonderful industrial revolution inaugurated by Watt and Stephenson, and Fitch and Fulton, and Stevens and Hoe and the great crowd of great inventors succeeding them completely effected, and the people, relieved from the distresses which unavoidably characterize such violent social changes, happily settled down to their legitimate pursuits, the peaceful acquirement of the comforts and luxuries of life, of

the blessings of education, and of all the refined pleasures which are the peculiar possessions of an enlightened people.

We shall, we may be sure, then see in each advancing year more of the beneficent influence of the advancement of science. Discoveries will succeed each other with ever-increasing rapidity; the now independent sciences will interweave themselves more and more thoroughly, gradually growing into a shapely and perfect whole; the foundation of schools of science will become yearly more frequent, and systems of instruction will be continually improved, until the progress of scientific knowledge among the intelligent classes of our people is only limited by the rate of advance of experimental science.

It is not too much to hope, even if it be too much to expect, that those among us who may be favored with life to the end of the nineteenth century may witness wonders beside which even our telephones, our phonographs, our microphones and our star-detecting tasimeters shall seem commonplace inventions; beside which the "Hoe perfecting press," the present locomotive engine and the mightiest of modern steamships will appear as rude as now do to us the press of Franklin, the halting colliery engine, or John Fitch's steamboats—the wonders of the beginning of this period. In effecting all these changes, in producing every improvement, every advance in civilization, in everything that aids the human race morally, intellectually or socially, the part to be played by the scientfiic man has an importance which can not be exaggerated. He is to furnish the worker in every department of life with a knowledge of the facts and the laws of nature upon which every profession and every trade is based. His is the noble mission to study the works of his Maker. To him alone it is given to read the great book of nature—the only existing infallible commentary on God's written word—and he alone can authoritatively respond to that momentous question, "What hath God wrought?" whether asked by the layman or the professional theologian, and whether it has reference to the objects visible to the eye and to the processes in operation all about us, observable to the senses, or to those opposite infinities which are revealed to us by the microscope and the telescope.

The mission of science is one, the scope of which we cannot fully comprehend and appreciate, but every worker in science and all lovers of science may at least see that it is transcendently important that we should more thoroughly study philosophic methods of science-advancement and seek in every possible way to promote the work of the observer as an investigator, of the philosopher, of the educator, and of him who embodies in useful inventions the knowledge made accessible to him through the advancement of science. It is by studying the science of science-advancement that we shall most effectually prepare ourselves to do our share of this great work.

The next paper, read by Professor Grote, was entitled "Education a Success of Experiences." We give it in full:

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EDUCATION A SUCCESSION OF EXPERIENCES.

BY PROF. A. R. GROTE, BUFFALO, N. Y.

LADIES AND GENTLEMEN: The two Vice-Presidential addresses of my predecessors are remembered for the honor they reflect upon American science. That of Prof. Morse, at the Buffalo meeting, two years ago, had for its subject, "What American Scientists have done for Evolution." This address has a permanent historical value, which is only lessened through the modesty of its author, who forgot his own in enumerating the labor of others. That of Professor Marsh, at the Nashville meeting of last year, dealt with the "Succession of Vertebrate Life in North America," and its sketch of the progress of the higher forms of life, however the details may be filled out by subsequent researches, established the certainty of that development by succession as the result of the author's own enduring work. In this address I have endeavored to trace the action of evolution in a further stage, and, in speaking on "Education and the Succession of Experiences," to lay before you a brief study of the growth of the mind.

A study of the phenomena of the human intellect teaches us that there is a process going on by which external matters are being pictured in the brain through the action of the senses. The imagination itself is found to depend upon an ideal grouping of experiences, however fantastic and unconnected they may be made to appear. As time elapses and mankind advances, the brain pictures seem to become more perfect and to embrace more fully the characters of their originals, and their development in this direction is proved by our varying notions of things and our changing conduct toward them. Education may, then, be primarily conceived as the process of storing sense-impressions in the brain, and the total condition and amount of the brain-pictures we might style knowledge. An education seems to resolve itself at last into a succession of experiences, however complex it may appear in its results, so that, in any discussion, it will make the matter much clearer it we study the machinery which makes education itself at all possible. It is evident that we only appreciate sight or any one other of our senses, because it exists; and in the evolution of sense organs, the feeling of the want of them in the individual evidently succeeds their possession of the species. Through the senses a section of the universe is opened to us, a section which is limited by their powers in bringing, and the capacity of the brain for storing what is brought. But with the utmost exercise of our receptive powers our view of the world remains a section still. When we find, for instance, that vibrations of the air below thirty-two and above 100,000 per second make no impression on the human ear, we understand that we are cut off from a wide range of possible sound. So that every mechanical appliance by which we can enlarge the field of experience tends to increase our knowledge, and, therefore, to affect our conceptions of the world about us.

The "atoms" of the intellect are thus seen to be the single sense impressions, and the conclusion is inevitable that reason is generalized experience. It is possible to check the correctness of this conclusion through a study of the intel-

ligence of the lower animals, and the efficiency of their senses. And so far we have found that the generalizations of knowledge which they are able to make, and which we have called in the past instinct, to distinguish them from our own reason, stand in direct relation to their capacity of receiving sense impressions.

It may be said that what the lower animals do know, they come to know by similar means and in the same way that we acquire knowledge, It is now the generally accepted conclusion by scientific minds that instinct and reason differ in degree, and not in kind. Our literature is already full of proof, drawn from the habits of vertebrate and invertebrate animals, that this position is a just one and explains fully the relationship between the intelligences of the different animals themselves, as well as between the intelligence of the races of men and that of lower types of existence. Reason is, then, built up out of past experience, which we use when brought into fresh contact with things. We become more reasonable as we experience more, and the object of education is to impart that reasonableness more quickly, so that the growing generation may not be obliged solely to find how things are from the slow process of its own experience, but profit by the knowledge which was gathered by those who passed away before. Reason, then, depending on the sense impressions, must be affected by the character of the sense organs. If these were more perfect the acquirement of knowledge would be easier. In fact, they are found to be limited and unreliable beyond what we might at first be inclined to grant. But however justly we may distrust our senses on any particular occasion, we can not consider them, or any one of them, as totally unreliable. All that we can do is to point out their insufficiencies, to check the evidence of one sense by that of another, to try by repeated experiment to establish the actual condition of affairs.

The pictures which our senses give us are not to be regarded as false although they may convey a misleading idea of the object perceived, Every action of the senses gives us a comparatively true perception of external objects. A correct judgment is formed after a full examination through all the senses that can be brought to bear on the subject, and in this way the actual state of affairs may be discovered. The method of examination we may employ is determined not only by past experience, but by that analogy which prompts fresh experiments. At bottom this is what makes education attractive, that the mind grows in the direction to receive more and more complete pictures of things. And this is an answer to those who object to scientific hypothesis, that all such, based on observation or sense-impressions, are to some extent reliable and serviceable. It is not true, either in part or wholly, that we "take leave of our senses," to construct our scientific hypothesis, but the reasonableness of our hypothesis stands in relation to the extent of our acquaintance with its subject and related matters. But aside from the imperfection of our senses, which may make a correct judgment impossible, or at least difficult, we find ourselves sometimes under exciting conditions of the brain, when we mistake the subject of our thought for the object of our sense-impressions. False seeing and false hearing have come to be classed among the diseases of the brain, and the evidence collected on this

head points to the conclusion that it is the memory which is here affected. The explanation of memory is, that it is the result of an effort of the mind by which we recollect the pictures and impressions already stored in the brain. The mind, "that veiled enchantress," as Draper calls her, is "veiled" because her feeders are so subtile, that we believe she exists without subsistence. But in all her phases she is seen to depend literally upon the senses for her vigor. The dream-doors of night's dwelling, opening at the touch of sleep, let forth a troop of images seemingly of fresh import, and perhaps of direst consequence. But reason, by simply bringing the figures into their proper sequence, reveals in them the pictures of the day's experience. Before discussing the imperfections of the senses, and which so deeply affect our conceptions, let us briefly consider the way in which one of them, that of sight, receives its impressions and conveys them to the brain.

Young, in his theory of the perception of color, has shown that there are three orders of pointlets or nerve ends of the retina, and that each order of nerve ends is sensitive to a different rapidity of the light waves. Helmholtz demonstrates that certain of the nerve ends in the retina are destructively affected, in both the live and the dead subject, by particular rays of light. We may conclude that the shape of any object, as it appears to us, depends upon the number of pointlets of the retina affected by it, and the color on the order of nerve ends stimulated by it so far as our sight of the object is concerned. The cause of the color of any particular object itself must be sought in the structure of its atoms, which absorb certain of the rays of light and reflect others. Thus all objects may be considered, in a general way, prismatic; that is, they effect a separation of the rays of white light in displaying the phenomena of color, but they do this by absorbing certain of the rays. This is the point where the chemist and the biologist meet—every phenomenon displayed by an object is found to depend upon the ultimate structure and arrangement of its component atoms. We may thus conceive of the action of the sense of sight without calling to our aid anything but the thing seen, the medium through which the thing attacks the eye and the machinery which conveys the picture of the retina to the brain, where it is registered. We may in this way investigate the action of the remaining senses, and with a similar result. Always there is the thing perceived, the media, the contact, the machinery of the sensory nerves and the gray matter of the brain. Defining education, then, as the process of receiving a series of sense impressions and experiences, let us consider in what way our knowledge is affected by the limitation and imperfection of the senses.

We have said that, from the limitation and imperfection of our senses, but a section of the universe is opened to us; in reality, we have but a partial idea of even this section. It will occur to every one that there are a large number of objects which they fail to take cognizance of, although they could do so if they had the opportunity. Such objects as distant portions of the earth's surface, foreign animals and plants, many of us have to content ourselves without seeing. We know them through the senses of other persons, who have written on them.

Nevertheless, our total conception of the world is affected by our personal ignorance of these matters which go to make up the world. But, aside from this class of objects, there are also to be considered the large number of things we pass over from inattention and a want of preparation of the senses to entertain them. How large a class this is we can easily understand when we know that the difference between scientists and other people is involved in the matter. For a scientist is merely one who diligently observes things that for the most part are neither seen or heard or felt by others. Life is also too short to witness the outcome of many things, and the years in which we are willing to pursue inquiry too few. It has happened that generations have elapsed before a new age has carried on seriously the investigations commenced at an earlier epoch.

The eternal appearing and disappearing of things, of which we are a part, it requires all our courage and genius to face and understand. And then, as to the limitations of the senses, we know from the microscope that there are quantities of forms too small for us to know without artificial help, and even correctly with it. We do not recognize objects at a certain distance, and our power of vision is probably surpassed in this respect by hawks and eagles. In similar ways, all our senses have their limitations, which it is the object of art and science to attack in the interest of human advancement. Aside from their limitation as to power, our senses are apt to deceive us, by taking only a particular side of the object, one view, as it were, from which alone we must receive a permanently incomplete, and therefore incorrect, idea. Again the same sense obtains different results under different conditions, as when Pythagoras observed that a stick placed in the water appeared to be broken. We contrast the picture of the stick in the water with its picture in the air, and although both pictures are seen to be correct, we test the truth by the sense of touch and arrive at the conclusion that the stick appears to be broken in the water. This illustrates what I have said before as to our testing the results of any observation by different senses. In this case this testing gave us the theory of the refraction of light and thus enlarged our conceptions of the properties of matter. In an address before the Russian Entomological Society, to which I have only space to allude, Von Baer most interestingly shows how our total conception of time itself is modified by the rate of the circulation of the blood. It is only another instance of the dependence of our conception upon our constitution. So far as we are concerned, we have reached, not the ideal, but the final truth whenever we have exhausted our powers of conception in any given direction and, by a systematized checking of results, arrived at a conclusion. The duty of accepting this conclusion and acting upon it seems to me imperative and is what science demands. Anything short of this is a practical denial of the value of all knowledge, which would lead to the disintegration of society. I hope to show, further on, that science assists the development of the whole State, and adds to the stability of government by publishing its conclusions, and wish to insist here that it is fundamentally beneficial to the same interests in making its observations. But from this imperfection and limitation of our senses comes, not only a succession of experiences which

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are incomplete, but a general conception with regard to external matters, which must be of necessity misleading. We are here but a short time and see but little of the outcome of passing events, and can know nothing of the outcome of the world itself. Thus it has come to pass that what we have not fully observed, we have assigned to an unknown cause, We have fitted nature into our own measure, directly led thereto by the imperfection of our knowledge, and we have arrived at the concept that design exists in the world about us as it is displayed in our own handiwork and the work of animals, which, with ourselves, exhibit design in their operations. But in reality what we see in the details of the structure of animals and plants is not design, but adaptation. Suppose we leave a coat in a closet, and while it is there it is visited by a female clothes-moth, which deposits thereon numerous eggs, The little worms hatched from the eggs would at once commence to make free with the nap, and eat holes in the coat with a good appetite. If they ever thought about the matter, would they not conclude that the coat was hung there for their special benefit? They would do so merely because the coat was there. The fact that they adapted it to their own use would be construed by them into a belief that it was designed for their benefit. They would inevitably regard the owner of the coat, could they arrive at this conception, as their benefactor and the preserver of the whole race of maggots. They would know nothing of the thousands of clothes-worm eggs that perish because they never get anything to eat. The fact that life is sacrificed by the wholesale in nature tells against the argument of design. And nature is as careless of the species as of the individual. In the crust of the earth are contained the remains of millions of types of forms of which nature has not been careful, but has crushed them out because they could not adapt themselves to the changing conditions which surrounded them. And just as the human body displays an incomplete adaptation as seen in our possession of useless parts, such as the vermiform appendage, which is present also in the anthropoid apes, so our sense organs are seen to be affected. The hyaloid artery of the eye, present in the earlier and already absorbed in the latter inter-uterine stages, is sometimes persistent after birth. Liebreich records in the transactions of the Pathological Society an instance of the persistence of this artery in a boy of sixteen. In New York Dr. Callam found three cases of persistent hyaloid artery in examining the negro school children, and it is a question if this disability is not more frequent in the inferior races, as, indeed, we should expect it to be. There can be no design in an imperfect sense organ, but imperfect sense organs nevertheless exist. And, indeed, any study of the eye is incomplete without studying the eyes of lower animals. In studying the development of flounders, Prof. Alexander Agassiz found that at a certain stage of growth the right eye sunk into the tissues of the head, penetrating into the space between the base of the dorsal fin and the frontal bone. Prof. Agassiz has been able to follow in one and the same specimen the transition of the eye from one side of the head to the other. With this change in the position of the eye is associated a change in the position of the body when swimming, for before this the flounder swims vertically, but at this time they com-

mence to lie on one side. We may conclude with Wilson, that since this distorted condition is shared in a lesser degree by a variety of other fishes, and thus a succession of steps is furnished, it points to an adaptation by an inheritance, although it is possible that there is a nearer solution to be drawn after we know the habits of the flat fishes more fully. But throughout the scale of animal life the senses are seen to adapt themselves everywhere to their surroundings. The eye which in man is moveable in its socket, and has a pupil which may be dilated to accommodate itself to the different rays of light, ceases to present these and other adaptive characters as we descend the series of animal life. We come at length to the special series of blind animals, such as the eyeless crab, *Willemoesia*, found by the Challenger expedition in the ocean depths, which wants even the eye, stalk and pedicle, and seems to have no occasion for sight, where the light will no longer penetrate.

To the conception of design is linked the idea of creation out of nothing. Both arise from the limitation and imperfections of our sense organs, and my thesis is that creation and design, as opposed to evolution and adaptation, are the results of being satisfied with the surface impressions we receive, and not checking and testing the results we may obtain from one only source of knowledge. There are certain Indians in the West, of whom Major Powell tells us, who believe that grass grows but that trees are created. And among them are likewise certain philosophers who think that both grass and trees grow, and who have a hard time of it in consequence, and with whom some of us in more civilized society may sympathize, though at a distance. It must not be taken for granted that even the slightest extension of the conception to include trees makes intelligent men out of these Indian philosophers; it shows that there are many grades of intelligence in this direction. The sources of intelligence are so various that we cannot come to understand the result as displayed by the individual without knowing more facts than we can get at. If we know the environment we can know the individual, and this fact is virtually admitted by all students of character. But to know the environment! how difficult, one is tempted to say, how impossible! But, perhaps, we can follow out our argument and at the same time attempt some classification of our knowledge, which will assist us in the study of the effect of the environment on the mind.

We have seen that we may conceive our knowledge as the total results of our sense impressions, and education as the process of acquiring these impressions. When we examine the sources of our knowledge, it will be found, I think, that we have attained it in two kinds of ways, and that for convenience and a better understanding of education itself, we may take these two ways as a rough classification of our knowledge itself. The one is by direct experimental contact with things, and this is the most positive and certain, so that we may call the knowledge we acquire in this way real. The other way is through books and the teaching of persons other than ourselves, and we may call this kind of knowledge second-hand. In the process of education we draw upon both these sources of information, and both go toward determining our total mental status. They are,

in fact, so interlaced that we have difficulty in separating them. What we have read about often seems only to be separated from what we have experienced by its lesser vividness, and the art of teaching evidently lies in the power of presenting second-hand knowledge so that is has the force, or nearly so, of an absolute sense presentation. Undoubtedly there is a certain ease and facility in acquiring second-hand knowledge which renders the process attractive to the mind; the mind, which, as we have said, grows in the direction of receiving information. But this second-hand knowledge carries with it the greater possibility of error. We have only to recollect that our second-hand knowledge is imparted to us through the machinery of words, and words, we all feel, but approximately express our ideas. This fact supplies the reason for the success of object-teaching in education. Undoubtedly the second-hand information of to-day is not the best information now possible, but, as a whole, it compares favorably with the second-hand information of twenty years ago.

From the fact that the vast majority of us acquire our conceptions of external things largely during our school and college days, there is an evident reason for the popular unfriendly attitude towards new ideas drawn from experiments unknown to the past generation of school children. Between this second-hand information and real knowledge there is seen to be a constant inter-action; the first is always improved by the results of the latter, and so mankind is instructed as time elapses. The proceedings of our scientific bodies contain a mass of information which is brought later on into our school-books in different shapes.

The effect on the minds of the rising generation is cumulative, and most children start with ideas and a presentation of facts with which their parents perhaps finished their education, and few of us, we know, actively pursue our studies during mature life. But here we must be struck with the fact which a study of the inheritance of certain faculties of the mind present. Much, we know, almost everythin,g is transmitted from the parent to the child, and along with the copy of the structure, the resemblance is carried out into minor details of form and feature. And in the same way the structure of the brain, which we yet fail to well understand, is affected. The faculty for receiving a certain class of brain pictures rather than another, the bent of the mind in a certain direction, follows with the color of the hair and eyes and the shape of the skull. But this faculty may exist and at the same time an absence of the brain-picture, which would satisfy and fill it, may cause its obliteration in the child from disuse. We must then clearly distinguish the factor of heredity as affecting the sensory nerves and the brain, when we consider the total mental condition of the individual. The action of the senses and the exercise of the brain beyond a certain extent, which varies with the individual, are painful and therefore distasteful. Up to what point they may be carried in any given case is difficult to determine. Sufficient it is for us to appreciate that, for the mass of mankind, a small total amount of sense and brain work suffices, and that we are generally willing to avail ourselves of the less tediously acquired knowledge which we receive through books. And even these it is almost usual to read carelessly and to avoid comparing, taking the remarks of author after author

listlessly into our minds, until our reason is clogged with contradictory impressions and our total mental attitude becomes feeble and vacillatory. And here this fact presents itself, that in proportion as we apply to the sources of our real knowledge, and generalize from the results of our sense impressions, we are able to criticise our second-hand information, and work toward a truer apprehension of ourselves and the world we live in.

Those who rely chiefly upon second-hand knowledge in effect refuse the present opportunity, which is alone their own, and must necessarily accept a lower philosophy of their lives. And by philosophy we mean, after all, an explanation of ourselves and the world in which we are. The range of meaning in words is so great that ordinarily we conceal under this term one knows not how much that is mysterious and that may be even held unnecessary. But by philosophy we evidently mean that correlation between the brain-pictures by which that which is contradictory is explained or brought into its true succession. We all know how comparatively easy it is for us to entertain contradictory beliefs, and how we do not even notice this contradiction until we come to compare our ideas, which we do not all of us try to do. But something of a philosophy we all of us attain to as the natural result of our sense impressions. As we rise to general conceptions we bring this philosophy to bear upon them, and we are apt to answer very difficult, even unanswerable questions, in a way which at once measures our knowledge and tries our judgment. Even when our philosophy gets damaged by facts we go about with it and wear it in some fashion, still preferring the old cover to the exertion of getting a sounder one from new sense impressions and a sounder correlation of ideas. But our philosophy or mental condition towards the rest of the world is of vital importance, since from it we derive much of our happiness. A life is of en wearily spent in struggling to face even very ordinary mental difficulties, in the endeavor to reconcile our experiences with our derived ideas.

What is needed, then, is some more accurate comprehension of what we are and to what things are tending, and to get at this we must lay under contribution all the possible sources of knowledge. From a conscientious application to the evidence of our senses we may come to some certainty of what things are and have been, and from a careful study of literature we may find out the direction of development in human affairs. The result of both these lines of investigation to the student is a culture as high as the amount of labor he has expended, and a happiness as complete as his mental development is equal sided. In any event this culture will be found to confer upon its possessor immunity from many of the sorrows of this life.

But obviously this total happiness depends on the correctness of this, his philosophy upon which it rests. A picture on the brain, received how it may be, if partial only, is nevertheless lasting, and has its effect in deciding the mental tone. And from these incomplete pictures we arrive at false or incomplete conceptions. In this way the persistence of ideas may be explained by the persistence of the physical impress on the brain and the mental labor requisite to alter or erase such a partial and misleading picture is always great. Great in any

event, it becomes too heavy a task for many of us when the pictures have most of them taken this turn. We are then committed to a wrong view of life, and must suffer the consequences. We must share in this event the average happiness which the defective philosophy to which the pictures lead us ensures. And the way in which pleasure and pain generally arise is the same as the way in which they come to the sense organs and the nerves. Pain arises in the body when any sensitive portion is torn or interfered with, and again where the wearing of the tissues is greater than the supply from the blood of the waste, as in being tired, or hungry, or thirsty. Pleasure arises from as vigorous an action of the organs of the body as can be maintained without expending more force than is supplied to the tissues and nerves from the blood. And exactly in the same way, by wear and tear, we find our senses affected. So that the conclusion is inevitable that the injury we inflict on the total organism from undue exercise of the senses is as pernicious to its proper development as excessive muscular work would be. The intellect, as distinguished from the emotions, is that part of the mind which discriminates and appreciates differences, but this fails us, too, after severe studies. A hard example in arithmetic, for instance, and a difficult feat in gymnastics present similar demands on the system; and at a certain age, indeed, the amount of vital repair necessitated by the first may be greater than that demanded by the second.

To trace the growth of the human intellect from before the earliest historic period until the present time is a work of immense labor and is one that is engaging the attention of the greatest minds. I can only attempt in a simple way to give here the more evident marks of its progress as seems to me approximately correct, and which I have on another occasion brought briefly before this Association. But before doing so, we may refer to our present knowledge with regard to fossil man. In a late address Dr. Virchow has seen fit to dispute the value of this evidence as bearing upon man's evolution from a lower type of animal life. In effect, the evidence being fragmentary, is also to some extent contradictory. But leaving out of sight the proofs from American sources brought together by Prof. Morse in his address before this Association, Mr. Henry Gilman's researches in Michigan, and the subsequent dicoveries of Dr. Abbott in the gravels of New Jersey, I wish to point out that the capacity of the skull is no absolute criterion of the intelligence between certain limits of measurement. As a fact the heaviest brains yet known did not belong to persons of the greatest mental power. Whatever, then, the capacity of the prehistoric skulls of Europe, the implements which their owners fashioned, the relics which we possess of their social life, are proofs of the low intelligence of these ancient men. Whatever their brains might have weighed, the direct evidence is that these people were far below the races that have succeeded them, in knowledge. The opportunities of the cave-dwellers were not golden, but flinty, their experiences few, their lives poor. Unless we are willing to cancel all we have yet gathered from antiquarian sources, we must admit that the evidence, as it stands, makes directly for the argument of mental evolution. And looking at this change in the minds of men

through the historic periods, and which is going on to-day, we may trace it to the material causes, because we must consider that education and intelligence have a material basis, as I have tried to show in this address. And we cannot separate in any essential way the development of the mind and that of the body, the one being conditioned by the other. That development seizes on certain organs or parts of the body especially, we know from the studies of Profs. Marsh and Cope, among our own Palæontologists, and it is quite clear that in man the development of the body has for some time been less active than the development of the brain. It is the immediate environment, which acts on the organism, and man, in social communities, is no longer chiefly dependent upon muscular vigor, but upon mental activity, for a successful existence. But corroborative evidence of the development of man from a lower type of animal life, so far as his physical development is concerned, we find in the fact that for every bone, muscle, or organ in man there is a corresponding one in the anthropoid apes. It must not be left out of sight that any special distinctions of this kind between man and certain apes have been found totally wanting. All the differences now recognized, including that of the cubical contents of the brain case, have been found to possess only a comparative value from their range of variation in different apes and in different men. This much we can, therefore, clearly show, that the difference between man and certain lower animals is a quantitative and not a qualitative, one. With this and the arguments from embryology and from mental evolution, the case of the total development of man stands, we must think, on very firm ground, even without the assistance of the analogies to be made with the development of other organisms, and without drawing on the possible future discoveries of palæontologists, the character of which might be justly inferred from what has been already presented.

A work of immense labor it is to unravel the network of complex thought which surrounds us to-day, and determine the origin of the separate threads. Such a labor is comparable to that of the biologist, who, through a succession of different but allied species of animals, traces the origin and modifications of a bone or muscle. But so much exists upon this subject already that I have ventured to give the material points of our mental progress, which may possibly assist us in our conceptions of the successive stages through which the mind of man has already passed. At the outset we cannot too strongly insist upon the comparative value of such terms as "civilization." Our general tendency is to give a fixed value to such words, measuring them by our own standard, and to this unconscious action, which has a wide application, and from which nothing but culture will free us, deeper thinkers have given the name anthropomorphic. In this instance, since our civilization is constantly changing, we can only consider ourselves as standing on a plane of comparative excellence, while a comparison of our own with the civiliza ion of the Chinese, Hindoos and Japanese shows us that in some few points, it may be, we have a lesson to learn; while in others, as in the character of criminal punishments, these nationalities occupy ground that we have abandoned centuries ago. The motor of civilization must always

consist in an improvement of the machinery for the exchange of thought. This follows from our conception that our intelligence results from our sense impressions on the brain, and that we understand by education the process of acquiring these brain-pictures. Clearly, the acquirement of articulate speech marked the first advance in human communities in mental evolution. It does not appear that we know how articulate speech came to us, although we may hope that in the disintegration of vocal sounds by some such invention as the phonograph, a reasonable theory of its successive steps may be brought out. The first marked advance upon the formation of language lay in the discovery of the characters of writing which we call phonetic, the steps to which were marked by the use of different grades of object signs. Through the invention of writing, a man's experience in this world was not lost when Death struck him dumb. For the earliest writings we have retained a special reverence which lasts until to-day, and has not been dissipated by extended familiarity with the process. The next step lay in the invention of printing—always following the same line of advance which mental development had marked out from the first, the growth of the mind toward receiving more and more perfect brain-pictures of external things, and the effort to assist this growth through the dissemination of ideas. Before the invention of printing, an important part of the process of education was limited to the few, because these alone possessed the art of writing and the means to secure collections of manuscript of different kinds. Hence the difference between ancient and modern civilization lies chiefly in this, that in the former the masses could be improved from outside of themselves by the orator. The printing press, at a later time, enabled the people to take the orator home with them, and review at any time his messages. In ancient times writing required to be read, and the stated re-reading came to be a custom in public before the action graced the hearth at home. So we may consider the advance of mental intelligence to be marked by these three great inventions: speech, writing and printing, while in our own day the spreading and perfection of our intelligence has been aided by the kindred inventions of the telegraph and telephone. Civilization thus appears as the consequence of the dissemination of experiences among mankind.

Those who have brought together the story of the ancient civilization of Greece have agreed with unanimity that the separation between the mass of the people and the intellectual portion became at length insurmountable, and finally led to national destruction. This makes for our own view, that it was to a defect or incompleteness in the machinery for the dissemination of knowledge that we must ascribe the dying out of the older States. An intellectual aristocracy was established in Greece, which, in order to maintain its superior position and from natural and selfish motives, endeavored to prevent the spreading of new facts, but it was assisted in this action by the limitation which an ignorance of the art of mechanically duplicating writing threw around it. Philosophers have explained the fall of Greece by considering it as a necessary step in the progress of humanity and the perfection of a future bloom of knowledge. And so in one

sense it may be, but still, exactly where the defect lay and where there is a positive advantage in the conditions of modern civilization and wherein modern civilization more adequately protects the State, has sometimes escaped them. To understand this fully we must come back to natural history, to anthropology, at last. A large class of persons with a certain bias persistently decry our modern civilization and look for its more or less speedy evanishment, merely because Rome perished and Greece decayed.

But nowhere in nature is there exact repetition, and to understand the new civilization we must remember that it rests on a larger average intelligence, brought directly about by the discovery of the art of printing. There is then a distinct reason, a scientific ground, for the opinion that our present civilization rests upon a surer basis than did those which preceded it, and this we may safely bring forward in the cause of truth. For science is in danger always of being regarded as the enemy of the State, because it tends constantly to modify existing ideas. But if we can show the necessity for a constant modification of our ideas, arising out of our own constitution, then it may be seen to be unreasonable to defame those who follow the search for truth. And it being undoubtedly true, as Locke says, that of all the men we meet with, nine out of ten are what they are, good or evil, useful or not, by their education, we can see how wide reaching the effect of our improved basis of civilization must be upon us as a people, and how important it is to understand the real direction in which it works.

But, indeed, the position I have tried to sustain in this address lies outside of any criticism of modern education. I have tried simply to show the way in which our modern civilization has grown up, and its real superiority over ancient culture. From this we may rest assured that science, while it influences, can never be an enemy of the State, and that the danger of the State, as well as other social systems within the State, will lie in the direction of an opposition to scientific truth and the right reason of mankind. But it remains for science to play a distinct part, in the discharge of its full duty to the community, by popularizing its discoveries. Doing this, it will insure the stability of the State by increasing the general information of the people. Through the instrumentality of publications, particularly such as the New York *Tribune Extras*, the *Popular Science Monthly*, and the *American Naturalist*, this work of reaching the people is being specially undertaken. But indeed the work of science is being aided generally by the newspaper. And in this work an association such as that we enjoy can take an active part by giving popular lectures. There rests upon us, then, a responsibility deeper than the perfection of our own knowledge—we have to spread it in the interest of the whole state. Gratitude to those who generously entertain us at our annual meetings, should at least prompt us to give in return the knowledge we possess in its easiest shape, while we may confidently hope that in so doing we are aiding the prosperity and peace of our common country. And beyond these there is the future Man for whom we are always working, and who is to be wiser and happier than we can ever be.

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The demand has come up from teachers throughout the country that they should be informed as to the manner in which the sciences should be introduced into the schools and the matter be taught. It is the duty of this Association to furnish the information. If we have not sympathized with this inquiry in the past, let us assist it in the future. It is quite evident that the sooner this Association commits itself as a matter of principle to the furtherance of science among the people, the more following it will have and the greater influence. And if it does not it will fall behind its peculiar duty and out of the line of advance in human thought. This Association must be prepared to demand more time for scientific studies from the public school authorities, and it must show to every one that education is a matter which not only falls properly under its cognizance, but which it is also prepared to take hold of. This Association should no longer delay to bring all its forces to bear upon the question of science as applied to education. While it does not do so it will always seem to shirk a duty and ignore one chief end of its existence.

Adjourned.

On Thursday the Association met at 10 a. m., and after transacting some routine business adjourned, after which the following papers were read before sections A and B and subsection C:

Prof. F. W. Clarke, of Cincinnati, Chairman of subsection C, on chemistry, delivered an address on

THE CULTIVATION OF CHEMISTRY.

To the members of this subsection the economical achievements of chemistry are familiar as household words. As we look about us in our daily lives, we see in every direction the fruits of chemical investigations. Every scrap of metal, all paints, oils, varnishes, fats and fertilizers, every bit of glass or porcelain, every cake of soap or box of matches, embodies some improvement which our science has made. Our linen is bleached and our outer garments dyed with the products of the laboratory. Whether we burn candles, gas or kerosene, we still have chemistry to thank for the cleanliness, convenience, brilliancy, purity and cheapness of the light. In many articles of food and in a long list of medicines, in the photograph and the galvanic battery, by the conversion of waste rubbish into objects of use and beauty, in short, through a vast network of improvements and discoveries, our still infant science has established its claims to recognition as a benefactor of mankind. Would that the multitudes who have enjoyed these benefits might see their sources as clearly as we do! Then would science be fostered and encouraged, where now it struggles feebly to secure a grudging and scanty support.

(Prof. Clarke illustrated the value of chemical inventions by the well-known Le Blanc soda process.) In 1814 sal soda was worth $300 per ton. In 1861 it had fallen to $22; 5,000 tons per year were produced, and over 10,000 men employed in the process. Since soda is used in the manufacture of soap and glass, these articles were proportionately cheapened and the demand for them greater. The application of the process created a new demand for sulphuric acid, and so

stimulated that industry and every other in any way depending upon it. In short, the results of the Le Blanc process, direct and indirect, can be traced into nearly every department of human industry, and they have been exclusively beneficial. Thus each discovery of the chemist is like a grain of corn, small in itself, and yet a germ from which may spring the food of numberless future generations.

In every science there is some central line of growth to which all details are subordinated, and along with its fundamental principles find their readiest and most logical development. Without such a main stem a science would be but a mass of scattered details, isolated facts, fragmentary principles, with little coherence or order. In physics, the doctrines of the conservation of energy and of the correlation of forces are points on the central line. In natural history the theory of evolution indicates a main stem. How is it with chemistry? Among chemists to-day there seem to be two schools. One school seems to take an interest only in the statical side of the science; its chief aim is to prepare large numbers of new compounds, and to theorize upon their constitution. It is as if chemistry were to be defined as the science of speculating upon the possible position of theoretical atoms within imaginary molecules. The other school may be described as essentially dynamical in its ideas. It sees in every chemical reaction three objects of study: the substances which enter into the reaction, the phenomena which occur during the reaction, and the substances finally produced. The second term, which involves all the transpositions of energy, is to them of equal importance with the others. They strive to see each change in all its relations; to study processes as well as results; to recognize the connection between chemistry and other sciences. This method of study is plainly the deepest and broadest, and includes all there is of value in the other. This feeling, I believe, is justified by history. Much of the progress of chemical science has been on the physical side. Chemistry and physics are one at bottom and cannot be truly mastered apart. Either, stripped of the portion it owes the other, would be poor indeed. They are branches from one common line of growth. One of the main objects of science is to render prevision possible. The more thorough our knowledge, the better are we able to predict discoveries, and to tell what lines of research will be most fruitful. The line which leads most directly to definiteness and precision is the true line of growth for us to find and to follow. Exactness renders prevision possible. To-day, notwithstanding all her brilliant achievements, chemistry is an inexact science. In experimental resources it is wonderfully rich: in delicate methods of investigation no science can surpass it; but in those principles which render foresight possible, chemistry is poor and meager. We may guess the existence of some undiscovered compound, but, until we have actually prepared it, we can tell nothing of its properties. We are, in fact, but laying the foundations of a future science which shall be to the chemistry of to-day what that is to the alchemy of the past. All that has been done by the chemist for humanity, has been done in spite of difficulties and defects; but enough has been done to prove the possibility of more. There are in chemistry three central problems upon which all else depends: 1. What laws govern the transformations of energy

which occur in chemical changes? 2. How are the proportions of compounds related to those of the elements contained in them? 3. What is the nature of chemical union? These must be studied together, each in the light of the other two. They need for their solution severe experimental researches, the exact determination of numerical data, and reasoning of a rigidly mathematical kind. Speculation should be used only as a line by which parts of the work may possibly be helped and guided. We already know tolerably well *what* transformations of energy occur in chemical changes; the question now is as to their quantitative relations. How much heat appears or vanishes in any given reaction; what is the exact electromotive force of any specified couple; what numerical expressions connect actinic energy with particular combinations or decompositions; these are questions that science now asks, and for which, in a few cases, she is beginning to find answers. If we are to determine what general laws connect the properties of compounds with those of the elements contained in them, we must first secure a large mass of well-established data to work from. For a very large number of substances all the physical constants must be rigidly determined, over and over again. With such data we may reach the desired laws; without them we can see but very little. Fragmentary researches of this kind have already been carried out, but very imperfectly. The discrepancies among existing data are amazing. Some of them may be due to bad work, others to undiscovered allotrophy or isomerism. Of all the measurements upon which we now rely, at least three-fourths should be re-determined; and even then our material would be insufficient. The research of this kind most immediately needed is the accurate determination, quantitatively, of all the physical properties of all the so-called elements. This would supply evidence directly bearing upon all three of the great problems. Such work has not yet been done for even one of the sixty-five elements now known. Take iron, for example, upon which so many practical experiments have been made; in these more purely scientific relations we know it only on the surface. Not a single series of physical constants has yet been rigorously determined for it. The reason for such incompleteness is evident. Hitherto the labor of research has fallen upon the shoulders of volunteers who have worked independently of each other. Part has been done by teachers in their moments of leisure; part by manufacturers or inventors with reference to practical problems. Our pure science has grown unsystematically, and our applied science has been imperfectly applied.

What chemistry needs is a combined effort upon some general plan. Much would be accomplished by an endowed laboratory for research, in which a trained corps of specialists should co-operate upon those investigations which are too large and arduous for individuals to undertake. In such a laboratory the physical properties of substances could be accurately measured; methods of measurement could be tested and improved; the quantitative relations of the forces could be exactly ascertained. By the precision thus gained in science, every industry involving the applications of science would be directly benefited. The special problems of the iron master might not be touched, and yet evidence would be

discovered enabling him to solve them more easily than before. The practical as well as the scientific value of the institution would be enormous. Can not this conception of a laboratory for research be realized? In every city there are rich men who owe their wealth to applications of science. Surely some of the riches she has created ought to return to her benefit. Every day we hear of large gifts to colleges, museums, hospitals and other charities, and there must be men who would give liberally to aid our science if they knew of her needs. Let the nucleus of such a laboratory as I propose once be established near some large university, or in connection with the Smithsonian Institution, and it cannot fail to grow and become a national glory.

In Europe the needs of science are provided for by Government. Here it might not be judicious to ask the nation for a laboratory of research. Still, there is one other kind of laboratory which Congress might properly establish. Our Government is continually obliged to employ experts in chemistry for researches in connection with the public service. Nearly every department in Washington has work of this sort to be done. It is now done in a scattered way, with imperfect means, and often less thoroughly than is desirable Would it not then be a measure of true public economy for the Government to establish in Washington a thorough laboratory, in which the public work might be done? The work must be done somehow, and would be better done in this way. Such a laboratory, properly manned and equipped, would be of direct material value to the public service, so that the question of its utility could never be raised.

In conclusion. Prof. Clarke urged upon his associates the importance of establishing in this country a good chemical journal. The researches of American chemists are steadily increasing in number, extent and value. Work like that of Wolcott, Gibbs, Cooke, Lawrence Smith, Mallet, Remsen, Jackson and a dozen others, we may well feel proud of. At present this work is scattered in various periodicals, and some of it effectually buried out of sight. We need a good chemical journal, in which all the work done in this country shall be fairly represented. We might have a periodical equal to any in the world; and it is to be hoped that we may not have to wait long for its establishment.

Prof. Clarke, chairman of subsection C, on chemistry, presided, and Prof. Thurston read "Notes on Antimony Tannate," by Mrs. Ellen S. Richards and Miss Alice M. Palmer, of the Massachusetts Institute of Technology, Boston.

The regular session of Section A was resumed, Prof. Thurston presiding. Albert A. Michelson, Ensign United States Navy, Annapolis, read a paper on

"EXPERIMENTAL DETERMINATION OF THE VELOCITY OF LIGHT."

This paper was considered one of the most important before the section, but it is impossible to present a proper idea of it without the diagrams accompanying it. But three scientists, Foucault, Fizeau, and, more recently, Cornu, Mr. Michelson said, have sought to ascertain accurately the distance of the sun from the earth. Foucault used the method known as that of "Wheatstone's Revolving Mir

ror," the application of which was first suggested by Arago. Fizeau and Cornu both used another method, known as that of the "toothed wheel." In Foucault's experiments the distance traversed by the light was twenty meters. The result obtained by him was 185,200 miles per second. Cornu's stations were about fourteen miles apart. The result obtained by him was 186,600 miles, which exceeds the former by 1,400 miles. The objection to Foucault's method is that the displacement, which enters directly in the formula, is very small, and therefore difficult to measure accurately. The objection to Fizeau's is that the time of total disappearance of the light was necessarily uncertain. The object of Mr. Michelson's experiments is to increase the displacement in the first me hod. This can be done in several ways: (1) by increasing the speed of the mirror; (2) by increasing the distance between the two mirrors; (3) by increasing the radius of measurement, i. e., the distance from the revolving mirror to the scale. In Foucault's experiments the speed of the mirror was four hundred turns per second; the radius of measurement was about one meter, and the distance between the mirrors was about ten meters. The displacement obtained was about 0.8 millimeters. In Mr. Michelson's experiments the speed of the mirror was but one hundred and thirty turns per second, but the radius of measurement was from fifteen to thirty feet, and the distance between the mirrors was about five hundred feet. The displacement obtained varied from 0.3 of an inch to 0.63 of an inch, or about twenty times that obtained by Foucault. With a greater distance between the mirrors and a better apparatus he expected to obtain a displacement of two or three inches and to measure it to within one-thousandth part of an inch. Tables of observation of the velocity of light in air were given by Mr. Michelson, the mean result being 186,508 miles per second. Mr. A. G. Heminway, of New York, contributed $2,000 for the purpose of carrying out these experiments.

The members of Section A of the Association were so pleased with the labors of Mr. Michelson that it was determined to use all endeavors to get Congress to make an appropriation to enable him to make further experiments.

On reassembling, after a recess of half an hour, Prof. Thos. R. Baker, Millersville, Lancaster county, Pa., gave experiments in an improved method of ringing a bell in an exhausted receiver. Prof. Chas. A. Smith, of Washington University, read a paper on

THE ECONOMIC USE OF STEAM.

The following is a summary of the paper: In the use of heat converted into mechanical force by means of the steam engine, so many points arise and such complex problems are found that any paper within ordinary limits will, of necessity, be incomplete. In the ordinary process of converting heat into mechanical work the following operations are always gone through with in order:

1. The development of heat from the fuel by the chemical actions taking place in the process of combustion.

2. The transfer of the heat there developed to some fluid, usually water, causing certain changes in the fluid.

3. The transfer of a portion of the fluid from the place where it receives heat to some place where, by change of volume, it can do work.

4. The change of volume of a portion of the heated fluid whereby the heat is converted into mechanical force.

5. The transfer of this mechanical force to certain contrivances or places where it may be used.

6. The means for using the force thus transferred.

Now, each of these operations is, in itself, a great study, and each of them has absorbed the great life work of many earnest men. Yet, to the ordinary mind, a great confusion still exists concerning these widely distinct processes, and it is oftentimes convenient to look only at the results, as from the commercial standpoint; but he proposed briefly adverting to some of them in order, and to illustrate such points as may be brought up by examples gathered from various sources. The difference in burning soft and hard coals were considered, as also the great evil of using too much air in the furnace, which has been clearly shown by experiments in this city. [This was afterwards confirmed by the Vice President.] The various losses of heat caused by the excess of draft, radiation from furnace and boiler were then discussed, and methods of suppressing them indicated. After this the losses caused by wire-drawing and throttling with clearance, were adverted to. After this the subject of cylinder condensation was taken up and credit given to Mr G. B. Dixwell and Prof. Whitaker, of Boston. The action of steam in a cylinder was discussed under various hypotheses, and the little gain to be expected from the addition of a condenser to a high pressure engine under the usual conditions was explained and the causes indicated, and the extra precautions required for the use of steam expansively were pointed out. The discussion of the action of the compound engine was brief and explicit. The whole paper may be summed up in the statement that the writer wishes to have the fire as hot, use the steam as hot, and keep it as hot as possible till it has been used, and to use it to as great a range of temperature as can be found practicable. The paper included extensive tables of boiler and engine trials.

Prof. Thurston then read a paper on

"FRICTION AND ITS LAWS, DETERMINED BY RECENT EXPERIMENTS."

He quoted the generally accepted law of friction, as stated in the text-books, as follows: "The resistance offered by friction, where two bodies, forced into contact, slide upon the other is directly proportional to the pressure, and is independent of the area of rubbing surface, and of the velocity of rubbing" This law, the Professor said, although approximately correct for solids, sliding one upon another, provided no abrasion takes place, is quite incorrect beyond that limit. It is also entirely incorrect as applied to lubricated surfaces. In this case the resistance follows an entirely different law. Where two rubbing surfaces are lubricated with oil, it is obvious that they, being separated by a fluid film, the resistance to the relative motion is not due entirely, even if at all, to friction of

solids, but must be produced by the resistance of the fluid to molecular disturbance, since with good lubrication the solids are kept apart and out of contact with each other by an interposed film of lubricant. It is therefore evident that the resistance to motion must follow a law intermediate between that governing the friction of solids and that of fluid friction, approaching the latter more closely as the lubrication is more perfect and the separation of the solids is more complete. Under such conditions, two limits may be noted to the law governing resistence under ordinary circumstances 1. When the pressure is made excessive the unguent is forced out, and the solids coming in contact, abrasion occurs, producing a sudden and great increase of resistance. 2. When the pressure is diminished a limit is finally reached at which the resistance to motion is due to the viscosity of the unguent, and this is still effective even when the rubbing parts are relieved of all pressure. The law of variation of resistance is then that of fluid friction merely. Speaking of friction with varying motions, the writer said Prof. Ewing had suggested that there probably existed a law of increase of friction with decrease of velocity which holds good throughout the whole range of velocities down to zero of motion, when the co-efficient of friction of motion changes, by a continuity of variation, into that for starting from rest. The writer, however, found the change from the one condition to the other to occur very suddenly at all ordinary speeds at the instant of coming to rest, and the friction at the instant of stopping is always much below that of starting, although greatly in excess of that for motion at all speeds in ordinary work. A great variety of tables were submitted, illustrating the amount of friction under various conditions. It was shown that the variation of pressure produces a very great change in frictional resistance, as measured by the co-efficient. A diagram of a machine, devised by the writer, was shown, with which it was attempted to secure a means of placing the lubricant under precisely the same conditions of actual service, and at the same time to provide facilities for observing its behavior, and of obtaining exact data. This machine was exhibited at the Centennial.

The following papers were read before

SECTION B:

Ancient Mounds in the Vicinity of Naples, Scott county, Illinois. J. G. Henderson.

Ancient Glacial Action, Kelly's Island, Lake Erie. Chas. Whittlesey.

On Hybrids in Nature. Thos. Meehan.

Notes on the life-history of the Blister-beetles, and on the structure and development of the genus *Hornia*. Chas. V. Riley.

On the larval growth of *Corydalus* and *Chauliodes*. Chas. V. Riley.

Description of two Stone Cists discovered near Highland, Ill. Arthur Oehler.

Description of a Cliff House in the Cañon of Mancos River, Colorado, with a ground plan of the structure. Wm. F. Morgan.

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Remarks on the Ruins of a Stone Pueblo on the Animas River, New Mexico, with a ground plan. Lewis H. Morgan.

Observations on the San Juan River District, as an Important Ancient Seat of Village Indian Life. Lewis H. Morgan.

On the Sources for Aboriginal History of Spanish America. Ad. F. Bandelier.

Of these two papers, the last one—by Mr. Bandelier—was considered to be very valuable, and will be printed in full in the Association's Transactions. Mr. Henderson's paper on the Naples Mounds was elaborately illustrated by diagrams, and by a unique collection of curious mound relics, such as pipes, celts, etc. One of the stone pipes, representing a paroquet astride a stem, attracted great attention.

The entomological papers of Prof. Riley manifest so much original research and careful study that we present full abstracts of them both.

NOTES ON THE LIFE-HISTORY OF THE BLISTER-BEETLES AND ON THE STRUCTURE AND DEVELOPMENT OF HORNIA.

BY PROF. CHARLES V. RILEY.

(*Abstract.*)

At the Hartford (1874) meeting of the Association, Mr. Riley described the newly-hatched larva of some of our common blister-beetles; but all attempts to trace their habits had proved futile both in this and other countries until 1877, when he discovered that they preyed on the eggs of locusts (*Acrididæ*). In a paper published in the last volume of the Transactions of the Academy of Sciences, of St. Louis, the life-history of several of our common blister-beetles is traced. The present paper gives a brief résumé of the facts there recorded, showing that the beetles belonging to the genera *Epicauta* and *Macrobasis* go through the same curious hypermetamorphoses as do other species of the family *Meliodæ*, and especially as *Melæ* and *Sitaris* were already known to do. The larva hatches as an active, pale-brown, long-legged creature, termed triangular on account of the three-clawed tarsus. It then changes to what Mr. Riley calls the *Carabidoid* stage, in which it is white, less active and fleshy; then to what he calls the *Scarabæidoid* stage, in which it is still more degraded and clumsy; then hardens to what he calls the *coarctate larval* stage, in which it is perfectly helpless and resembles the *puparium* of many Diptera; then to the final larval stage, in which it is again white and soft and more or less active; then to the true pupa state; and, finally, to the beetle; existing, thus, in eight distinct states, (including the egg,) instead of the four in which ordinary insects occur.

The paper is principally devoted, however, to the life history of a very anomalous, wingless genus of this family, the *Hornia Minutipennis* of Riley. This insect is degraded and subterranean, and was found in the cells of a common mason bee, the *Anthophora abrupta*, Say. Its life-history, which was not known at the time the species was described, has been completely made out by

Mr. Riley the present summer. The eggs which are laid loosely in the burrows of the bee hatch during the early part of June. The triungulin is extremely active, and, in all essential characters, very similar to that of *Sitaris*, one species of which, in Europe, likewise develops in the cells of *Anthophora*. By means of its tarsal claws and of a pair of pre-anal spinnerets and claspers, it holds on very tenaciously to the hairs of the bee, and is carried on the same into the bee-burrow. When the bee-egg is laid, and before the cell is capped over, this triungulin disengages itself from the bee and at once pounces upon the bee-egg. After having sucked the contents of this last it throws off the triungulin skin and assumes the *carabidoid* stage; thereafter feeds upon the honey-paste stored by the bee, and, within the cell, goes through all the hypermetamorphoses characteristic of the family. All the latter stages, however, take place within the puffed skin of the *scarabæidoid* larva, the *coarctate* larva being well separated therefrom, but the third or final larva having such a delicate skin that it is not easily separated from this last when shed. There is but one brood annually; the pupa state being attained in August, and the beetle maturing all its parts during the autumn, and lying within its numerous coverings until the following May.

The paper contains some interesting details as to the effect of rain both on the bee larva and the *Hornia* larva; on the vicissitudes that befall the triungulin, its fratricidal propensities when two or more are inclosed in the same cell, and on its adaptability to food-supply.

ON THE LARVAL CHARACTERISTICS OF CORYDALUS AND CHAULIODES AND ON THE DEVELOPMENT OF CORYDALUS CORNUTUS.

BY PROF. C. V. RILEY.

(*Abstract.*)

The paper relates to the development of one of the most singular and interesting of North American insects—the largest of the order Neuroptera. In its perfect state this insect is a great, clumsy, nocturnal fly, popularly called Hellgrammite, and characterized by the jaws of the male being converted into a pair of long, curved, cylindrical and tapering prehensile organs, like the finger of a grain-cradle. In the larva state it is aquatic and much esteemed as fish-bait by fishermen, who call it a "crawler," "dobson," etc. Indeed, one of the most popular artificial fish-baits is a patent india-rubber imitation of it. This larva is very peculiar in having in its latter stages three distinct sets of breathing organs, viz: the ordinary spiracles, a lateral series of long, single bronchial filaments, and a ventral series of spongy branchiæ, composed of numerous branching and tractile filaments. The eggs of this insect are laid to the number of about three thousand in curious masses on the leaves and branches of trees, or upon any other object overhanging water, and were first described by Prof. Riley at the Buffalo (1876) meeting of the Association. After comparing the eggs with those in the female abdomen, and the newly hatched with the mature larva, he felt quite certain as

to the parentage of the curious eggs. Yet the newly hatched larva which he described differed from the mature larva in lacking the ventral branchiæ, resembling in this respect the mature form of another aquatic larva of an allied genus (*Chauliodes*), and as some leading entomologists believed that the eggs described by Prof. Riley might belong to this last genus, further evidence as to the real nature of said eggs was desirable. The paper presents this evidence and confirms the previous determination. The *Corydalus* larva is traced through its stages of growth and then compared with that of *Chauliodes*. Several interesting scientific facts are brought out. The larva undergoes about six molts. The double nature of the thoracic tracheæ in *Corydalus* appears in the first larval stage, and the branchial nature of the lateral filaments is proved by the tracheæ leading to their tips. The ventral branchiæ first appear in the second stage (after first molt) and from three main stems each with bifurcate or trifurcate filaments. The branching filaments become more and more numerous and complex with each molt. The tracheæ also lead more and more strongly to these ventral branchiæ and less strongly to the lateral ones, with age. The stigmata are obsolete in the first three stages and in the fourth are only clearly distinguishable on the four or five larger abdominal joints, being still obsolete on the terminal ones.

The motion of the larva is invariably backwards. When newly hatched it moves actively about in the water by sudden sweeps of the abdomen beneath, very much as a lobster is known to do; and even, when full grown, a somewhat similar motion is employed in swimming. In the water a constant motion of the ventral branchial tufts is kept up, the main stem being first moved quickly backward and upward so as to bring the whole tuft close to the body, the filaments of which it is compo ed being then closely appressed to each other. The main stem is then brought more slowly down in the opposite direction, when the filaments spread and enlarge the whole to its utmost. In pure water the motion occurs about once a second; as the water becomes impure the motion becomes more rapid and the larva issues from the water as soon as posssible, being able to live out of water for several days even when only a few months old. Well developed ova are found even in the larva when only two-thirds grown.

The paper gives detailed comparative descriptions of the *Corydalus* and the *Chauliodes* larvæ. This last may always be distinguished from the former by having a smooth and unarmed skin; that of *Corydalus* has a skin roughened with granulations and capitate or clavate projections, overlooked by previous describers, the little points being visible even in the first stage, at which time they are less capitate. The *Chauliodes* larva has the last pair of spiracles on the tips of a pair of contractile filaments described as setæ by Walsh who failed to apprehend their real nature and wrongly described the *Chauliodes* larva as having one pair of spiracles less and one abdominal joint less than that of *Corydalus*, whereas both larvæ have the same number of joints and spiracles and both possess the rudimentary mesothoracic spiracle, which Prof. Riley finds more common in insects than is genrally supposed. In other structural respects as well as in the habits and transformations the two larvæ greatly resemble each other. The eggs of

Chauliodes have a longer tubercle or stem on the top, and are not covered with white albuminous material as are those of *Corydalus*. Prof. Riley has obtained large additional numbers of the egg masses of the latter the present summer, finding them not only on the leaves as described in his former paper, but on the stems of different trees, as well as on rocks overhanging water. He has had as many as twenty egg masses on a single maple leaf, both sides of the leaf being completely plastered up by them: and as a large number of these masses will generally be found in some one particular locality, or on a few branches of the same tree, the assumption is that the females congregate for purposes of ovipositson. The white, albuminous substance covering these eggs shows by analysis that it has all the physical properties of wax.

In the afternoon little or nothing was done, except that the committees of the sections met and arranged for to-day's papers.

In the evening a large number of members and citizens assembled in the chapel to listen to the address by the retiring President of the Association, of which we give the greater part:

THE COURSE OF NATURE.

BY PROF. SIMON NEWCOMB, WASHINGTON, D. C.

After announcing that he appeared as a peacemaker between the scientific investigators of the material manifestations of nature on the one side and the philosophers and theologians on the other, respecting the true theory of the course of nature, he proceeded at length to explain away the apparent differences between scientists and theologians by asserting that Science only concerns itself with phenomena and the relations which affect them, and does not take account of any questions which do not in some way admit of being brought to the test of observation, while the theologian looks upon the doctrines he has been taught as something, the truth of which is essential to the welfare of humanity, his idea of truth being symbolized in the pure marble statue, which must be protected from contact with profane hands, and whose value arises from its beauty of form and the excellence of the ideas which it embodies. He therefore looks upon those who attack it with feelings not unlike those of the keeper of the statue upon a chemist who refuses to see anything in the statue except a lump of carbonate of calcium of peculiar form, and who wants to handle it, weigh it, determine its specific gravity and its cohesive power, and test its substance with acid. The corresponding idea of the scientific investigator is symbolized by the iron-clad turret, which can not be accepted until it has proved its invulnerability. Instead, therefore, of being protected from violence as if it were a product of the fine arts, violence is invited. Its weak points are sought out by eyes intent on discovering them, and are exposed to the fire of every logical weapon which can be brought to bear upon them.

After still further elaborating this idea and declaring that the true scientific investigator tests every question under consideration by a more or less long and

painful examination, putting everything that can be found to militate in favor of it into one scale and everything that can be found to militate against it in the other and only deciding by the preponderance of evidence, he proceeds to the discussion of the subject, as follows:

Let us now approach our main theme, the course of visible nature. Let me again remind you that of the two universes, the seen and the unseen, I am only going to speak of the former. We find ourselves placed in this world in the midst of a vast theater of activity. We see an atmosphere agitated by storms; great masses of water rising in the air to form clouds, and, after falling to the earth, flowing as mighty rivers to the ocean; countless forms of vegetation rising from the earth and then returning to it; a sun vivifying one and perhaps more planets with its heat; an infinitude of chemical changes going on around us; countless stars moving through space with velocities which transcend all our conceptions. To all appearances, these operations have been going on for millions of ages past, and may continue for millions of ages to come. As the thinking man contemplates them he is led irresistibly to the conclusion that they do not go on at random, but that they were joined by connecting links, or are in some way the product of knowable causes. From his earliest infancy he sees connections between them which enable him to foresee results. He finds that fire burns, that the sun warms, that food satisfies his hunger and that heavy bodies fall with a certainty that shows the forces at play to be invariable in their action. To penetrate the mystery in which these forces are enshrouded, he exerted the efforts of his intellect from its first dawn in ages now forgotten until the present time. What general conclusion has he reached?

From the earliest times at which man began to think, two modes of explaining the operations of Nature have presented themselves to his attention. These modes are sometimes designated as the teleological and the mechanical.

The teleological explanation of Nature pre-supposes that her operations are akin to human action, insomuch as they are under the control of, and directed by one or more intelligent beings having certain ends in view; that the events are so diverted as to compass these ends; and, finally, that the relation of the events to the ends admits of being discovered by observation and study. This last condition is a very important one because without it the teleological explanation of the cause of Nature would not be a scientific one. The doctrine that the Author of Nature has certain ends in view, and directs the whole course of events so as to bring them about, will not enable us to explain and predict the events unless we know what those ends are. But, as I have already said, the test of scientific advance is the power of foresight—of foreseeing what result any combition of circumstances will lead to. If we always had to wait for the result, and could then only say, I know this is the result which was intended because it has happened, no actual foresight would be possible; and however excellent the doctrine might be as a theological one, it would not admit of being tested by observation and experiment, and the question of its truth would, therefore, not admit of being settled by scientific investigation.

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It must be well understood that the teleological theory of nature, or, as it is now familiarly called, the explanation of natural phenomena by design, has two distinct forms, the scientific and the theological. These forms are not antagonistic ones; one is held by scientific men, and the other by theologians; for, as you may well know, the scientific form is the one in which scientific men almost universally reject the teleological theory, while they have nothing to say against the other forms. The forms refer only to the fields to which the theory may belong, the scientific and the theological. The distinction turns on whether we suppose the ends which the Creator has in view to be discoverable by scientific investigation or to be inscrutable. Only in the former case have we, as scientific investigators, anything to do with the question. Now, as we shall more fully see hereafter, the number of ends supposed to be scrutable has constantly diminished, and the theory of design on the scientific side has narrowed its scope in proportion. The only scrutable end which nature is now supposed to have in view, is the good of living creatures, and especially of man, and even in this field we know so little about what is good for us individually, that we here have only a slight clew to the result. On the other hand, the number of events which directly or indirectly interest us is so great that thls slight clew may be supposed to lead to many knowable results, if we once admit the theory.

The other explanation of nature is the mechanical one. It assumes that her processes go on in accordance with certain laws which admit of being fully comprehended by the human mind so far as their effects are concerned. Each state of things is the effect of the state which immediately precedes it, and the cause of that which immediately follows it. The cause of nature is thus considered as an endless chain, of which the work of science consists in making out the forms of the links, and the modes in which they are connected. In this investigation we have to be governed by two things—the general laws of nature, as they are familiarly called and the facts or circumstances which determine the operation of these laws. This distinction is most clearly seen in human laws. Thou shalt not steal, is a law; that John has stolen, is a fact. The combined result of the law and the fact is that John is locked up in jail. So, that all bodies near the earth gravitate toward it with a force directly as their mass, and inversely as the square of their distance, from its center, is a universal law of nature. The Niagara river and the precipice are facts, and the cataract is the result.

But the general explanation of the course of nature, on the mechanical theory, is not of this kind, because the laws of nature do not act singly, but in combination, so that the result of each is modified by the action of all the others which come into play. The law of gravitation is not that all bodies must fall, but only that they tend to fall, and, therefore, will fall unless held up by some sufficient opposing force. So long as I support this weight in my hand it does not fall, because the force of gravitation and the resistance of my hand neutralize each other. But the instant I let go, the weight drops, according to a certain law known as that of uniformly accelerated velocity.

The doctrine I am endeavoring to elucidate is this: Knowing a few simple

laws of nature, of which gravitation is one; knowing also the arrangement of material things within the field of investigation; that is, knowing the facts, we can predict with unerring certainty what the result will be; or, if we cannot predict it, it is not because of any quality of the thing itself, but only because of the insufficiency of our powers. Moreover, these results will be, as it were, another layer of facts, from which it is possible to predict new results to follow them, and so on without limit, unless some facts from without intervene to change the cause. If we include the whole of nature in our field, no outside facts can come in, and her course, therefore, admits of being predicted with entire certainty from beginning to end.

Now, the point which I wish to bring to your attention, is the revolution which modern science has brought to pass, in the opinions of mankind, respecting the relations of the two classes of causes or supposed causes which I have described. That all events could be explained on teleological principles, it is not likely that any one ever supposed. That the falling of heavy bodies, the running of rivers, the changes of seasons and the revolutions of the heavens were all in accordance with mechanical laws, at least so far as the phenomena are concerned, no one ever knowingly denied. But it was thought that the action of these causes was from time to time modified by the introduction of causes of the teleological class, just as a rock might be kept from falling by the force of cohesion. The general rule has been that the more ignorant the age the more minute and immediate was supposed to be the action of those beings who were modifying the course of nature in order to compass their ends.

As illustrating this I might commence with the age of image worship when the fate of the individual was supposed to be at the mercy of certain spiritual entities, symbolized by forms of wood, stone or wax. But leaving out of consideration ideas so different from those which prevail among us, let us come nearer home. It is not many generations since men who knew that the regular course of nature went on in accordance with mechanical laws believed, nevertheless, that occurrences of a terrific or extraordinary character were specially brought about to compass some end of Providence. Not only so, but, what is most essential to our theme, this end was supposed to be a scrutable one. The motions of stars and planets had gone on from age to age until no new aspect of them inspired alarm. But a comet was looked upon as a messenger specially sent to give warning of a coming calamity. The scrutable end was, in this case, the warning of mankind.

Ordinary cases of sickness and accident, whatever their result, are always looked upon as a part of the regular course of events. But it is not many centuries since the pestilence was believed to be specially sent by heaven to punish mankind for their wickedness. Punishment and terror were here the ends which Providence was supposed to have in view. The regular daily breezes and showers were supposed to be the result of natural laws. But these laws were not supposed to be entirely adequate to the production of the tornado, which was again a special messenger, and they were suspended, or their action was modified in time of extreme drought, threatening mankind with famine.

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These special messengers of heaven, have, one by one, yoked themselves to the car of natural law, so that I think I can hardly be wrong in saying that the supremacy of mechanical law, and its adequacy to account for the whole course of nature as we see it going on before us, is now the almost universal opinion of educated men. This revolution in human thought is, perhaps, clearly brought out in the different view we now take of certain religious observances introduced by our ancestors, whose ideas would now be considered as approaching the irreverent. Take, for example, the prayers for the right kind of weather, which we find in our prayer books. When they were first composed and inserted, their object was a purely practical one. As the farmers now sometimes fire off cannon to make the black cloud break and discharge its contents upon the parched field, so the prayers were to be offered up in order that the aqueous vapor in the air might be made to condense and fall. That a much more exalted view of prayer than this is now taken by the more enlightened portion of the religious world, I think we have every reason to believe.

Although we can hardly entertain a serious doubt that the mechanical theory of natural operation, or, as it is sometimes called, the doctrine of the uniformity of nature, is generally acquiesced in by the mature thought of intelligent Christendom, yet objections are frequently made to it because it seems to run counter to some of our most cherished ideas. If it were not paradoxical to make the assertion, it might be said that we hold, or at least express entirely inconsistent views on the subject. The fact is we are pupils in two opposing schools which are, in a certain sense, antagonistic, one of which we cannot, and the other of which we will not give up. In one of these schools the chief teachers are observation and experience. All sentiment and emotion are banished from its curriculum, which admits only the hard realities of the outer world. The older we grow the more we see and hear of this school, and the more unreservedly we accept its teachings. It tells us that the whole course of nature takes place in accordance with certain laws capable of expression in mathematical language; that these laws act with more than an iron rigor, and without any regard to consequences; that they are deaf to prayer and entreaty, and know no such thing as sympathy or remorse; that if we would succeed we must study them and so govern ourselves that their action shall enure to our benefit.

The other school is that of sympathy, emotion and religious faith. In it, as children, we receive our first teachings. It shows us ourselves placed, as it were, in a forest of mystery, surrounded by forms over which we have no control, and able to penetrate so little into the surrounding darkness that we cannot tell what shall happen to us on the morrow. It has, in all ages, peopled the thickets with invisible beings having an interest in our welfare or our injury, or with providential interferences designed to compass each, of which we in advance, have no conception. Its teachings are nearest and most welcome in times of affliction and fear. Its objections to the teachings of the other school are heard far and wide through the land. Notwithstanding the number of forms which these objections

take, their essence may be condensed into a very few sentences. The following will probably be accepted as a fair rendering of their substance:

You take a contracted and unphilosophical view of nature when you say that the world is governed by inexorable laws. These laws are not governors but only the instruments of government by which the real Governor executes His purposes. With them, but without subverting them or violating them, he can reward or punish, bring on prosperity or call down disaster according to the dictates of his sovereign will. The child and the peasant call the thunder the voice of God. The modern philosopher attempts to correct them by showing that it is the product of evaporation and of atmospheric electricity. But the view of the child is really the more correct of the two, because he ascends at once to the first cause and thus sees farther than the philosopher who corrects him, because the latter stops short at the immediate or secondary cause without even trying to raise his eyes to the higher source of power. I think I am not far wrong in giving this as the substance of the most cogent objections which may be anticipated in any quarter against the mechanical theory of the course of nature.

Now, if these views referred only to inscrutable first causes of things, or to the intelligent but invisible substratum which underlies the whole course of nature, we should have no occasion to discuss them, because they would lie outside the field I have assigned as that of our contemplation at the present time, and which I have sought to describe as the field of phenomena. The doctrines that all things go on in exact accordance with the will of the Creator; that he has certain ends which the laws of nature are designed to bring about, and that an intelligent cause lies behind the whole universe of phenomena, are of a class which science has no occasion whatever to dispute. If it were made clearly to appear that the field of the teachings in question was thus limited, and was entirely distinct from that of phenomena, with which alone science is occupied, there would be no occasion for dispute between the two schools. I have no disposition to throw a single stone across what I consider the sacred boundary line, nor to enter a field which I am by natural and acquired habits of thought unfitted to cultivate. As men of science, let us by no means attempt to penetrate a region in which the eye of science can see nothing but darkness. If we thus subject ourselves to the imputation of being "of the earth, earthy," we may console ourselves that our edifice is firm and durable, because it does not seek to rise into regions of serener air, nor to rear its dome above the clouds.

I can hardly be mistaken in saying that the objections to the mechanical theory of nature which I have just tried to formulate are not always confined to the field of inscrutable first causes. There is a part of the boundary line over which the stones are flying very thickly. While some of the combatants may profess to make no attack on the doctrine of the uniformity of natural law, I cannot but think that these professions often arise from a misapprehension of the scientific side of the question.

Indeed, I must confess that I have met with a difficulty from my inability to form a clear idea of the views really entertained by the school now under consid-

eration. I have made a somewhat careful study of some of the most elaborate works of the writers of the theological school devoted to this very topic, and I have left them without being able to decide in my own mind whether the writers do or do not hold unreservedly to the mechanical theory of the cause of nature. That nearly all intelligent men do not hold to this theory, at least so far as the present time and dispensation are concerned we have abundant reason for believing. Nor is there, even among advanced theologians, any lack of profession of a belief in the uniformity and supremacy of the laws of nature.

But, when thinkers of the other school maintain the doctrine, and trace it to its logical consequences, undisguised by sentimental language or figure of speech, they are met with criticism which I can account for only by supposing that the theologian understands by laws of nature something different from what is understood by the man of science. Let us try to condense the questions at issue into the smallest possible space. The scientific philosopher maintains that the natural course of events goes on in invariable accordance with what I have described as the mechanical theory of nature. He asks the theologian in the words of Pope—

> "Thinkest thou like some weak Prince the eternal cause
> Prove for his favorites to reverse his laws?
> Shall burning Ætna, if a sage requires,
> Forget to thunder and recall her fires?
> On air or sea new motions be impress'd,
> O blameless Bethel, to relieve thy breast?
> When the loose mountain trembles from on high
> Shall gravitation cease if you go by?
> Or some old temple, nodding to its fall,
> For Chartres' head reserve the hanging wall?"

To all these questions the other answers no, and thus all occasion for dispute ought to end. But it does not end, by any means, for he proceeds to criticise the views of the questioner on the ground of their narrowness, and to inform him that the Creator can (and, by implication that he does,) so arrange things that any result he may wish shall be brought about by the action of natural laws themselves. "We do not expect Ætna to recall her fires when a sage is near; or the air and ocean to acquire new motions to preserve a saint from danger." * * * Should these individuals not be rushing recklessly against the known laws of heaven, or should it be the will of God to preserve them, it will be found that provision has been made for their escape, and that not through the powers of nature disobeying their own laws, but through other powers in nature opportunely interposing to stop, to turn aside, or otherwise to modify their operation.

Now, always supposing that such remarks as these are intended to apply to the domain of sight, hearing and understanding, they differ fundamentally from the scientific theory in their view of what constitutes the laws of nature. The school seems to look upon causes and effects in nature as belonging to two different classes of things. They see an immense collection of causes, to each of which the appropriate effect is tied. So long as the cause is followed by its effect

the laws of nature are satisfied. So, if the Ruler wants to reward, punish, kill or rescue, He has only to bring into operation the appropriate cause at the proper moment; the natural effect follows and His will is executed without any violation of the laws of nature. I am not sure that this is an exact statement of the views to which I refer, but it is the best I can gather from the study of the forms in which they have found expression.

Supposing this to be the view really entertained, it is essentially different from that held by the scientific philosophy. The course of Nature, as it presents itself to the eye of science, is not a collection of isolated causes, each with its effect attached to it, but it is rather to be symbolized by a chain in which each link is connected with the link which precedes it and with the one which follows it. At each moment of time the state of the universe is the effect of the state which immediately preceded it and the cause of the state which immediately follows. There are no such things as distinct causes and effects, but only laws of progress, which connect the successive links of the seemingly endless chain.

As an illustration of this, let us take the falling of the rock. To the mere observer there is no evident reason why it should fall at one time rather than another; he may therefore feel that there is room for speculation as to the cause which made it fall at the exact moment it did. But science teaches that it will fall at the very moment when the cohesive attraction which binds it to the mountain behind becomes less than the weight of the rock. We might suppose a power so to adjust the causes which effect the cohesion that the rock shall fall at some desired moment. But any such adjustment would be as complete a subversion of natural law as if the power should hold the rock up after it had begun to fall. The natural processes by which the cohesion of the rock is slowly diminished, though largely hidden from our view, are governed by laws as precise in their action as those which regulate the motion of the planets. The water which falls from the clouds slowly percolates through the ground and enters a crack in the supporting mass. It wears it away at a rate dependent upon the solubility of the material and the quantity of water which falls. A constant but certain molecular action goes on without ceasing between each molecule of water and each molecule of rock. The strength of the latter is thus weakened according to some law admitting of precise mathematical statement. Thus, a mind possessed of sufficient mathematical ability, knowing how much water runs over the rock from time, to time, and knowing also the laws of molecular action between the rock and the water, could determine, long in advance, the very moment at which the rock would fall.

Going back another step, we see that the quantity of water which runs over the rock depends on antecedent circumstances in the same way, namely, upon the quantity of the rainfall and the arrangement of the crevices in the ground. However the latter may have been produced, the cause is still another link in the endless chain which we can trace back to preceeding links as far as we please. Equally is the rainfall a fixed element determined by the course of the winds and the amount of moisture which they carry. Thus we have a network of causes, too complicated for the human mind to trace in detail, but which the philosophy of

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science teaches us act with mathematical certainty. No tempering, modifying, or adjusting action comes in at any stage of the process, so far as we can see; if we admit such action we have to keep placing it farther back as our knowledge increases.

Now, there is one feature of these causes, the admission or rejection of which constitutes the main point of difference between the two schools of thought, which I have before indicated. All are agreed that the course of nature is determined by what we may call causes or laws, but all are not agreed as to the scope of action of these laws. The great and distinguishing feature which the school of sciences recognizes, and which the other school does not recognize, is that all the laws of nature act without any scrutable regard to consequences. I qualify my statement by the word scrutable, because it is entirely outside the pale of scientific research to speculate upon possible inscrutable ends in nature. This being a subject on which the man of science, speaking as such, can affirm nothing, so he can deny nothing. Having found that no trace of regard for consequences can be seen in the mode of action of the laws which he investigates, but that the whole course of things, so far as his eye can penetrate, may be explained and predicted without supposing any such regard, the demands of science are satisfied, and he must there stop.

Let me illustrate this by going over the train of thought which has just occupied us, in the opposite direction, starting from the rainfall, and tracing the succession of causes to the fall of the rock. The spot at which each drop of rain shall fall is determined by antecedent conditions entirely, by gravitation and the winds. The drop neither seeks nor avoids the crevices, never asks in any way what shall be its destiny after it reaches the ground. It strikes the ground wherever gravity and the winds bring it, percolates through the soil according to the law of least resistance, and dissolves the rock according to the laws of chemical affinity, without any respect to the consequences, immediate or remote. At length a moment arrives at which the cohesive force of the rock becomes less than the weight which urges it downward. This movement is by antecedent circumstances, such as the solubility of the rock and the amount of water which percolates over it. At that very moment the rock begins to fall. It falls sixteen feet the first second, three times that distance the next, and so on, according to the mathematical law of falling bodies, without any respect to the lovely character of the beings it may destroy or the disasters with which it may crush the fondest hopes of men. The region may be the wilderness; the passer-by may be a babe in its nurse's arms, an angel of charity fulfilling her mission of good will, or a murderer aiming the deadly blow at his victim, but under no circumstances can we see that these conditions in any way affect the chain of causes which lead to the falling of the rock, or cause it to wait a moment or swerve a hair's breadth from its inevitable course.

According to the theory of the course of nature, which I am trying to elucidate, the chain of causes which we have described, each cause acting according to antecedent conditions, but without any regard to consequences, is the type of the whole course of inanimate nature, as far in space as the telescope can pene-

trate, and as far back in time as the geological record can be deciphered. An essential feature of the theory is that the laws which connect the several links of the chain, and thus determine the progress of events, do not possess that character of inscrutability which belongs to the decrees of Providence, but are capable, so far as their sensible manifestations are concerned, of being completely grasped by the human intellect and expressed in scientific language. Without this the theory would have no practical bearing whatever, because, to say that the course of events is fixed, but by laws which we can never grasp, would give us no clew to learning what that course shall be, and would be equivalent to telling us that it is enshrouded in the same impenetrable mystery with first causes. A very important feature of the progress of science is found in the constant resolution of the laws of Nature into more simple and elementary ones, until we reach principles so simple that it is impossible to analyze them farther. Let us take as an instance of this, the laws of the celestial motions. When Kepler discovered that the planets moved round the sun in ellipses, having the sun in one focus, he found what were for his time simple and elementary laws. They were entirely comprehensible, admitting of being expressed in mathematical language. They enabled him to predict the motions of the planets, and so far as the intellect of the time could penetrate, they could not be resolved into more simple expressions.

But when Newton appeared upon the scene he showed that these and other laws could be expressed in the simple and comprehensive form of gravitation of every particle of matter toward every other particle with a force inversely as the square of the distance which separates them. All the laws of planetary motion which had before been discovered were shown to be reducible to this one simple law, combined with certain facts respecting the directions and velocity of the planetary motions. The most essential of these facts is that the velocities of the planets in their orbits are such that their orbits, under the influences of the sun's gravitation, are nearly circular.

By this grand generalization Newton reduced the laws of the celestial motions to a form so elementary, simple and comprehensive that no further reduction seems possible in our present state of knowledge. Attempts have been made to show that gravitation is itself the result of discoverable causes, but they appear to me entirely unphilosophical, since the causes into which they would resolve gravitation are more complex than gravitation itself. But for our present purpose it is not necessary to concern ourselves whether gravitation may arise from some more subtle principle as yet undiscovered. The point which I wish you to grasp is the entire comprehensibility of the law as it now stands. There is no mystery surrounding it. When I say that any body left unsupported will fall toward the center of the earth until it meets with the earth itself or some other obstacle to its further fall, you know exactly what I mean and what are the results of the law which I enunciate. In a certain sense we might say that the laws of nature are simply *general* facts distinguished from special facts by their dependence upon certain antecedent conditions. Considered as such there can never be any doubt as to their meaning or results. There is no profound philosophy involved in their

action or expression any more than there is in such statements as that all unsupported bodies fall toward the center of the earth; that gunpowder, when touched by fire, suddenly changes to an incandescent gas; that water, at ordinary pressure, changes to steam at a temperature of 212°.

Now, scientific investigators are earnestly endeavoring, each in his own sphere, to do for the whole of nature what Newton did for the laws of planetary motion; to find and announce the elementary principles which connect all the links of the endless chain which symbolizes her course. The student of chemistry can not doubt that the innumerable properties of the various compounds which he studies arise from the play of certain attractive and repulsive forces among the elementary molecules of the matter of which these compounds are formed. Could he only learn the law according to which these forces act, chemistry might become very largely a deductive science, and the properties of compounds might be predicted in advance as the astronomer predicts the conjunctions of the planets. The idea now entertained by those who see farthest in this direction is that all the physical properties of matter depend upon and may be reduced to certain attractive and repulsive forces acting among the ultimate atoms of which matter is composed.

It may also be supposed that all the operations of the vital organism, both in men and animals, depend, in the same way, upon molecular forces among the atoms which make up the organism. The operation of forces unknown to chemistry must, indeed, be presupposed, but there is no reason to suppose that these forces are less simple than chemical ones. Some would even go so far as to explain the facts of consciousness in this way. The philosophy of this explanation belongs, however, to another department of thought—that of scientific materialism—into which we cannot at present enter.

The most startling attempts in the direction I have indicated are those wh ch are designed to show that those wonderful adaptations which we see in the structure of living animals, and which in former times were attributed to design, are really the result of natural laws, acting with the same disregard to consequences which we see in the falling rock. The philosophy of Darwinism and the theory of evolution, will be at once brought to your mind as forming the modern system of expl nation tending to this result. On these theories the eye was not made in order to see, nor the ear in order to hear, nor are the numberless adaptations of animated beings to the conditions which surround them, in any way the product of design. Absurd as this theory appears at the first glance, and great as is the anxiety to secure its rejection, the question of its truth is to be settled only by a careful scientific study of the facts of nature and the laws of hereditary descent. The principle which is to aid in its settlement is universally admitted in quarters where it it is fully understood. We are not to call in a supernatural cause to account for a result which could have been produced by the action of the known laws of nature. The question then is whether these laws of hereditary descent and of natural selection are adequate to account for the gradual growth of such organs as the hand, the eye and the ear, and for all the adaptations which we see in na-

ture. If they are, it would be idle to call in any other cause, except we place it behind the laws, and if we place it behind those laws we must equally place it behind all others. Of course, such a cause lies beyond the field of sight and does not, therefore, belong to scientific observation. Granting the theory, then, so far the eye of science can penetrate, the whole result is brought about by laws acting in seemingly blind disregard of consequences.

Let us now turn once more to the theory of scrutable design, which supposes at least the occasional action of causes which the human intellect can perceive to have been intended to produce certain effects, such as the salvation of the righteous, the punishment of the wicked, the warning of the indifferent or the preservation of the race. Studying this theory from the purely scientific standpoint in all the varying forms in which history presents it, we see its distinguishing feature to be the idea of causes acting so as to bring about certain results.

(CONTINUED IN OCTOBER NUMBER.)

The third day's meeting (Friday) was made one of the most interesting of the session by the demonstration by Prof. Edison of his various inventions and discoveries, the paper read by Prof. Riley on "The Philosophy of the Movements of the Rocky Mountain Locust," and the descriptions by Prof. Barker of his observations of the late eclipse of the sun.

Among other matters of miscellaneous business Prof. Bolton reported from the committee to memorialize Congress in relation to meteorological researches. The report recommended that the committee be continued, and that Mr. Osborne, of Washington, be added to the committee, and that Prof. Loomis be requested to take the chair. Report adopted.

Profs. Newcomb and Baird, of Washington, and Prof. Meyer, of Hoboken, were appointed by the chair a committee to draft a eulogy upon Prof. Henry, as ex-President of the Association.

Prof. Putnam, the Permanent Secretary, announced that Prof. Wm. B. Rodgers had given a second donation of $100 to the Association. He was, on motion, made a life member.

The Standing Committee recommended that article 35 of the Constitution be repealed, in order to enable life members to receive the publications of the Association free. Laid over for a year.

Adjourned.

After the meeting of Section A, Prof. Barker introduced Prof. T. A. Edison, who was very warmly received by the audience and members present, and heartily welcomed by Vice-President Thurston in a very complimentary address, after which he proceeded to explain in a simple and lucid manner, aided by diagrams, the use of the Tasimeter in measuring the heat of the stars and the sun's corona. He also explained by means of diagrams on the board his new Volameter. It is useless to undertake to give the substance of these remarks in the absence of the diagrams.

After Mr. Edison had finished, two papers were read by Prof. Barker. The first of these dealt with the

SPECTRUM OF THE CORONA,

As seen by himself at Rawlins, W. T., on the occasion of the late total eclipse of the sun. Observations were made with a 4-sec. telescope, by Jones, of London, and a direct vision spectroscope, by Merz, of Munich, having 5 prisms, equal to two prisms of heavy glass, and working with a broken joint. After describing his apparatus, Mr. Barker said: "I moved the green portion of the spectrum into the field, but no line was visible. I then varied the width of my slit, opening and shutting it so as to see if the line of 1474 was visible, but although the slit was narrowed until the Fraunhofer lines were distinct and sharp, showing the instrument was in perfect adjustment, yet no 1474 line could be detected in the spectrum. I then moved the slit, or rather moved the telescope—for the telescope moved upon a center—I moved the observing telescope of the spectroscope over the spectrum three times from the extreme red to the extreme violet, but was entirely unable to observe any bright line whatever throughout the whole length of the spectrum. Prof. Draper observed the eclipse with a telescope of two inches aperture, in the top of which was placed between the objective and the eye-piece a prism of 45°, carrying a clear two inch beam. Using the prism thus in the telescope between the objective and the eye-piece, of course the appearance to him would have been of as many images of the corona as there were different refrangibilities in its light, and he supposed he would get two if not three rings. But the appearance was absolutely continuous. The spectrum was as clear and sharp and smooth as if he had used the whole sun. He took a first glance at that, and then at my request came to look through my spectroscope of higher power, moved it over the whole spectrum and said that the results agreed, and that the spectrum was continuous in my instrument, as in his. I then moved the slit over various portions of the sun's edge and placed it both longertially and radially. The observations of this line and spectrum were of course exceeding rapid, as must have been the case, and yet with no position of the slit that I could get was any light line whatever observed, except for an instant, when the slit crossed a small prominence observed upon the upper limb of the sun. The results, then, of our spectroscopic examination at that altitude, 7,100 feet, coincided with the results obtained by the photograph. The photographs of the defraction spectrum obtained at the same time by Prof. Draper, are absolutely continuous without even shading. Of course the 1474 line is out of the question in this case, because that line is in the green, and of course the green part of the spectrum is not photographically active, but no lines were obtained on the blue part of the spectrum by photography.

I am the more reluctant to make a very strong statement in regard to the absence of the line 1474, because I understand Prof. Young himself saw that line. I entirely defer to him. I can't exactly say that I don't believe I saw it, if he did, for that is not the business of a scientific man, but I am sorry not to see him here so I could ask him where he saw it, and for how long a time. A man of his experience and standing in solar physics, may—from the fact he has seen several eclipses before—have known about the adjustment and about the

position necessary to secure a good result. I simply state that with the means I used it was quite impossible for me to get a single bright line in the spectrum of the corona"

Mr. Barker's next paper was on "A New Method of Determining the Pitch of a Tuning Fork." At the end of one arm of the fork is placed an induction coil, through which passes a voltaic current, not strong enough to at all disturb the vibrations of the fork. The current induced by the vibrations of the fork operate a telephonic desk, with a stud-pin engaging with a cylinder covered with chemical paper. The tellurium point of the recording pin by contact with the ferrous-cyanide paper, leaves a black dot for each vibration registered. By comparing the register of vibrations with the register of seconds of time, the rate of vibration is arrived at with mathematical accuracy.

The following papers were read by Prof. J. W. Osborne: On the construction of a Sensitive Wind-vane. On Wind-vane Rotations. The Importance of Meteorological Observations in Vertical Section of the Atmosphere, with the suggestion of means for their systematic accomplishment.

The last paper in this section was "Magnetic Determinations in Missouri," by Prof. Francis E. Nipher.

PROCEEDINGS OF SECTION A.

Monday.—The proceedings in Section A were very interesting. Prof. J. W. Osborne made an address on "The Importance of Meteorological Observations in Vertical Sections of the Atmosphere, with the Suggestion of Means for their Systematic Accomplishment." Prof. Osborne pointed out the impossibility of taking vertical atmospheric observations with the present means, as the buildings of the observatories necessarily interfered with the currents. He did not think a balloon would meet the exigency, as it was impossible to secure it in a perfectly stationary position. He recommended the building by the National Government of a high tower, from two hundred to four hundred feet, on a prairie, where it would be away from disturbing influences.

Prof. Barker, on behalf of Mr. Edison, made an

EXLANATION OF THE CARBON BUTTON.

In his opinion, he said, the carbon button, the invention of Mr. Edison, was one of the most important discoveries, if not the most important discovery, ever made in this country. It was the nucleus of a whole crowd of inventions of Mr. Edison. It arose out of a long series of experiments, and had been brought to perfection only within the present year. It consists simply of a certain variety of lamp-black, which is compressed by a screw press in steel dies, to form a disk about the sixteenth of an inch long and over half an inch in diameter. In experimenting all forms and varieties of carbon and all conditions of condensation were used. It was found that the smoke of a mixture of kerosene oil and petroleum naptha, in equal proportions, burned in an ordinary petroleum

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lamp, the wick being turned so that smoke formed upon the chimney, which was collected, furnished the best material for the purpose. A quantity of lamp-black, exactly as it was taken from the lamp chimney, was exhibited in a bottle by Prof. Barker. The peculiarities of this material, he went on to say, are two-fold. (1.) It is the finest variety of lamp-black which can be artificially produced. (2.) Its great conductivity; it is quite as good a conductor as spongy copper. A certain quantity is weighed out carefully and placed in a steel die, and is subjected to a pressure of 1,200 pounds to the square inch. This constitutes the carbon button. He could not bring a specimen with him owing to its extreme frangibility. It can be used as a portion of an electrical circuit, as an electrical resistance, first, on account of the conductivity of the lamp-black, and, secondly, with the pressure which is exerted upon it. This electrical resistance varies in accord with sonorous vibrations. In practice it is placed in a small case, into which is dropped a little disk faced with platinum. Contact is made at the top and bottom with wire. It may be adjusted to any resistance within the range of its own limit which may be chosen. The limits may be varied also by the pressure employed in making the carbon button. If the pressure is increased, the sensitiveness of the button is very materially increased. The first practical application of the button was, of course, with the telephone. The problem involved in the telephone is, theoretically, a very simple one. There is an instrument at one end called a "transmitter," whose function it is to translate sound waves into electrical waves. At the further end there is an instrument called a "receiver," whose object is to translate electrical waves back again into sound waves. In the magneto-electrical telephone both functions are served by the same instrument. In all of the telephones now in use the same force which sends the current, or which produces the waves in the current, produces the current itself. A portion of the energy of the voice is used in producing the magneto-electrical current and another portion is used for the purposes of articulation. Prof. Maxwell gives it as his opinion that the telephone of the future will not be the magneto-electrical telephone, and for reasons which seem obvious enough. In the first telephone Prof. Bell used a battery, and used the voice to modify the current. However, in his case the battery current was excessively feeble, and did not produce such good results as the magneto-electrical current did. Now, the problem was to modify the current by the carbon button—to translate, by means of the carbon button, sound wave into electrical waves. The elucidation of this problem is an exceedingly simple one. The strength of the current is exactly proportionate to the pressure exerted on the carbon button. It does not matter whether this pressure is produced with the finger or the tongue. If a strong sound wave strikes it, there is a strong current; if a weak wave there is a weak current. There is an electrical current which copies faithfully every detail of the sound waves and sends them over the wire, and successfully translates the sound waves into electrical waves by means of the carbon button. The ordinary or any telephone may be used as a receiver, but Mr. Edison has invented a receiver of his own. An ingenious arrangement was explained, by which accidents

through "crossing" or lightning can be avoided. A "relay" instrument, invented by Mr. Edison, by which a primary current may be translated into a secondary current, was also exhibited. The carbon button can be applied as a barometer to a variety of other purposes.

After recess, Prof. Barker delivered an address on the principle involved in the microphone and the carbon telephone. He contended that the principle of of the two instruments was identically the same, and that Mr. Edison and not Prof. Hughes, of England, had priority of claim of discovery, although he did not imply that the latter was indebted to the former for the idea, but rather that it was a singular instance of contemporary experiments and almost of discovery.

The address was one of the most interesting that has been placed before the Convention, Prof. Barker possessing a peculiar faculty of elucidation.

Prof. Rees, of Washington University, read the following paper on

THE WORK DONE BY THE FORT WORTH SOLAR ECLIPSE PARTY.

This party was composed of Leonard Waldo, of Cambridge Observatory; R. W. Willson, of Harvard University; W. H. Pulsifer, of St. Louis; F. E. Seagrave, of Providence, and the speaker.

Fort Worth had been chosen as the place of observation for several reasons:

1. Weather reports obtained from Colorado and Texas showed the chances for clear weather to be better in Texas.

2. The totality came to Fort Worth fifteen minutes later than it was seen at Las Animas, and, therefore, it seemed probable that we would be able to show in our photographs, and, perhaps, the sketches, any great changes in the corona.

Mr. Wilson left St. Louis July 8 to arrange for the exchange of longitude signals between St. Louis and Fort Worth, and to make the needed arrangements for the party's work.

On the night of July 15 an exchange of longitude signals was made, through the kindness of Col. R. W. Clowry. Mr. Waldo, at this end of the line, made use of a transit instrument set up in the observatory of the Washington University. Mr. Wilson used a Stackpole sextant and subsequently a transit loaned by Brown University, Providence.

The rest of the party, except Mr. Pulsifer, reached Fort Worth on the 18th. Mr. Lomax, cashier of the City National Bank, generously placed his grounds, houses and horses at our disposal. The days before the eclipse were occupied with work on the adjustment of instruments and observations with sextant and transit for latitude and time. Mr. Willson had contrived a very steady sextant stand, which enabled Mr. Waldo to make observations on Polaris and Antares with great accuracy. Observers along the path of totality in Texas were requested to coöperate with our party; descriptive articles were written for the papers, and selections of Prof. Wm. Harkness' valuable instructions were printed and sent to each person desiring to act with us.

We readily established observers at Dallas, near Hearne, McKinney, near the

limit of shadow, Allen and Cleburne. Some of these observers were furnished with stop-watches. A class of some twenty sketchers was organized, under the direction of Mr. Waldo, and were trained in sketching from pictures of the corona —allowing them 2m. 30s. The practical part of the photographic work was put in the hands of Mr. Alfred Freeman, of Dallas.

The instrumental equipment of the party was as follows: Mr. Waldo had under his care the photographic apparatus, including two cameras arranged with double refracting prisms, loaned by Dr. Litton, after the suggestion of Prof. E. C. Pickering, for photographing any effect produced by polarization. Mr. Waldo also used a small telescope for observing contacts. Mr. Willson used a beautiful three-inch telescope, kindly loaned the party by E. Ellery Anderson, of New York City. Mr. Seagrave had a 5-in. Clark refractor to which he adapted his own spectroscope of 10 prisms by Browning. Mr. Pulsifer joined the party four days before the 29th, bringing with him his Clark 4-inch telescope and two spectroscopes, one of which was fitted to a spare 3-inch telescope belonging to Mr. Seagrave; the other was attached to Mr. Pulsifer's own instrument. I had in hand a 5th Alvan Clark spectroscope, loaned by Mr. Smith, of Boston, to which I had attached a very fine spectroscope (belonging to Waldo), of two prisms, and furnished with long collimator and telescope.

Although the weather for two days before the eclipse promised badly, yet on the afternoon of the 20th the clouds broke only a few minutes before the first contact, and we had a fine view to nearly the last contact.

In regard to the work done during the eclipse, Mr. Waldo reports as follows:

1. He saw the diffraction shadows flitting over the ground at totality.

2. First contact, 3 h. 11 m. 29 sec.; duration of totality, 2 m. 28.7 sec.; fourth contact, 5 h. 19 m. 16 sec.

3. The photographs show detail, though moved, because the small prominences are drawn out along the plate.

4. The corona was very different from any of the coronas drawn during preceding eclipses. The parts of it towards the North and South Poles of the heavens seemed pretty well defined, but the two ends which lay roughly in the ecliptic were very poorly defined, and probably extended much farther than the naked eye saw.

There was not visible at a glance any of the wonderful streamers portrayed during former total eclipses as radiating from the sun, but there were visible variations in the light from different parts of the corona, which gave the impression of unequal densities.

Mr. Willson, with the three-inch Secretan, with universal mounting, observed the first contact with terrestial eye piece, magnifying forty diameters, and noted the second contact with an inverting eye-piece of 150 diameters. During the partial phase both these eye-pieces were used. For third contact and during totality a power of about thirty diameters was used, the field of view being about 1° diameter. In this eye-piece was a glass plate ruled with concentric circles (by Rogers, of

the Harvard observatory) about 6 m. apart, whose circumferences were divided into arcs of 45° each by lines radiating from their common center.

Mr. Willson was also provided with an ordinary Arago polariscope, (Dr. Litton's) and with one of Browning's direct vision spectroscopes to be used as occasion should offer. Observations were made of all the contacts. Prof. Willson, in his paper on the subject, says: Just before the totality I replaced the darker shade upon the telescope by a light reddish glass and caught up the chronometer beat, watching for the contact with my left eye, my right being bandaged. Totality having commenced, I removed the bandage from my right eye and examined the corona. My first glance caused me great surprise. The moon's disk appeared surrounded by a reddish glow (with a slight orange tinge), much brighter towards the moon's limb, of uniform texture in all parts of the circumference, but fading gradually to a well-defined surface about four or five minutes from the moon's limb. Neither chromosphere nor prominences were anywhere visible; this was my first, and I must say, disappointing impression. Just as the timekeeper called 2:15, however, I discovered that I had forgotten to remove my glass shade, which I immediately did, regretting that I had lost fifteen seconds of precious time—perhaps not lost, I think now, for my observation of the portion visible through the shade may prove to be of use, and seems to discriminate between the colors of different parts of the corona, for as soon as I removed the shade I became aware of other portions of the corona whose light was very nearly as intense as that near the moon's limb, but which were invisible through the shade, while the ring seen with the shade, was not at any time distinctly seen without it. To my view the light of the corona varied somewhat in the different portions; and its outlines were very irregular, but well defined.

Of the protuberances visible, only one was of good size, extending somewhat more than a minute and a half from the sun and having somewhat of a sickle shape, the others were all small, but of a peculiar appearance. Mr. Seagrave reports that the thermometer fell 11° during totality. The first intimation of the moon's approach was given by Mr. Seagrave, who, intently observing with his spectroscope, called out, "Chromosphere gone!" Willson noted the contact six seconds later. Mr. Seagrave says he saw a continuous spectrum with one bright line 1,474, which was measured at the base. At the critical moment Mr. Pulsifer's assistant, completely overcome by excitement, was unable to lend him any help. An untrained man stepping in at this juncture did what he could. Mr. Pulsifer intended to use both of his spectroscopes with his own four-inch telescope, but experiment showed that too much time would be lost in changing. The single prism spectroscope was adapted to the spare three-inch Clark telescope, which had a very shaky mounting and stand. The direct vision spectroscope was fitted to the fourth Clark telescope. For the reason above named Mr. Pulsifer lost the spectroscopic contact. Removing his prism spectroscope and adjusting his solar diagonal eye-piece he observed the sun in partial eclipse; saw few faculæ; serrated edge of moon's limb very sharply defined; cusps clean cut; no brushes of light at cusps; granulations and faculæ extended close to moon's

limb. The direct vision spectroscope was fitted to telescope sometime before totality. New prominence lines were looked for, but none found. About three seconds before totality the slit was placed tangential to that part of the sun's image where the second contact would occur, narrowed and focused till the spectrum came out beautifully clear. The field covered the *c* line. At last there came an instant when it seemed that the spectrum entirely vanished, then a flash, and the lines blazed out bright, the whole phenomena occupying so short a time that no estimation of its length could be formed. Mr. Pulsifer describes the phenomenon as follows: I was startled to find the lines shortened at each end, and occupying not more than one-third or perhaps one-fourth of the width of the spectrum. I had never seen anything of the kind before, but was instantly reminded of Miller's maps of the ultra violet spectrum of platinum, but the lines were sharp, not nebulous, except that the ends seemed rounded off. It seemed to me that the *c* line did not shorten, or at least to such a degree as the other lines, and that it remained in sight for an instant after the other lines had disappeared. * * * In regard to whether prominences and corona are visible before totality, he says: I can furnish some information on this point. I observed the eclipse of 1869 from my observatory in St. Louis some twenty-five or thirty miles southwest of the line of totality. At that time I observed several prominences on the limb of the sun just at the points where the limb of the moon exactly (or nearly so) covered the sun's limb. I made a drawing at the time, but it has been mislaid or destroyed.

My own observations, Prof. Rees went on to say, during the partial phases showed the moon's limb very irregular, and, toward the center, affected by a slight undulation. This undulation was not communicated to the cusps, which were very sharply cut. In the extreme points both before and after totality, dots of light were observed, of the same color as the faculæ. During totality the spectrum of the corona, pointing the telescope to four points of the corona was always continuous, and the Fraunhofer lines *c* and *d* were plainly visible.

The light of the "wings" of the corona was varied, giving, to my eye, the appearance of parallel rays, and not radials. These wings were in the line of the ecliptic, and the rays were also parallel to the ecliptic.

The darkness during totality was not so great as I expected. I was well able to read fine divisions on my slit screw-head without any extraneous light.

Col. Lockett, of Tennessee, made the best sketch the party had, and a copy in oil of his sketch was exhibited by Prof. Rees. Prof. Barker showed the *Graphic* copy of Draper's photography of the corona, and compared it with the telescopic view by Mr. Willson.

Discussion on the paper was deferred until morning.

The chemical sub-section listened to the reading of a most valuable and interesting paper by Dr. J. Lawrence Smith, of Louisville, on the discovery by him of the oxide of a new element, for which he proposes the name of Mosandrum, a metal allied to the cerium group. This is the only element ever discovered by

an American, and is remarkable as not having been detected, as most of the latter elements were, by means of the spectroscope.

The next paper read before this section was by Prof. Riley and treated of "The means by which silk worm moths issue from their cocoons."

One of the most interesting articles in the room of this section was a photograph of a new fossil impression in a glacial boulder of metamorphic sandstone, found near Buffalo, N. Y., and exhibited by Mr. A. R. Grote. The impression is remarkable as being the only fossil mark ever found in a glacial boulder, and it is probably referable to some species of Protozoan allied to *Oldhamia.*

Two other papers were read by substitution; "On a Remnant of the Spectacles in *Amia* and *Lepidosteus,*" by Burt. G. Wilder. "The Development of *Amia,*" by S. A Forbes.

SECTION B

listened to the reading of the following papers:

Embryology of Clepsine (1) Stages preliminary to Cleavage (2) Cleavage, Germ lamellæ, Gastrula, etc., C. O. Whitman.

Extracts from Modern Science bearing on the Law of Repetition, Miss V. K. Bowers.

Richthofen's Theory of the Loss in the Light of the Deposits of the Missouri, James E. Todd.

Are the so-called Chætetes of the Cincinnati group Bryozoans? (read by title,) A. G. Wetherby.

Remarks on the Geographical Distribution of the land and fresh water Mollusks of the United States, and their local varieties.

Remarks upon the Archæology of Vermont, G. H. Perkins.

The Relation of Adhesion to Horizontal Pressure in Mountain Dynamics (read by title), H. F. Walling.

Some Indications of Recent Sensitiveness to Pressure in the Earth's Crust (read by title), H. F. Walling.

Remarkable Burial Custom from a Mound in Florida—the cranium utilized as a cinerary urn, Henry Gilman.

Description of a Glazed Earthen Vessel, taken from a tumulus in Florida, Henry Gilman.

Evidences of Cannibalism in a Nation before the Ainos in Japan, E. S. Morse.

The last three papers were read for their authors by the Secretary.

Just before close of the session, Capt. C. E. Dutton commenced the reading of his paper on the "Geological History of the Colorado River and Plateaus."

In the evening, at Mercantile Library Hall, Mr. Wm. J. Marshall delivered his lecture on the Yellowstone National Park, of which it is eminently safe to say that, in point of simple interest and magnificence of illustration, it surpassed any lecture ever given in St. Louis. There was a full house and a very critical audience; but, fastidious as they were, it was only necessary for them to see the

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views to burst out into applause. Mr. Marshall showed them a map of the National Park and told his audience how they could get there. Then, in very rapid succession, he displayed pictures of the famous Sentinel Rock, the Madison Falls, the Lower and Upper Geyser Basins, with views of the "Old Faithful" Geyser, Bee Hive Geyser, Pluto's Well, Specimen Spring, the Castle Geyser—a view more splendid, in point of fairy-like texture and brilliancy than any transformation scene that the stage ever saw—the Grand Geyser, some petrified grasshoppers, mud volcanos, the Yellowstone Lake, (view by moonlight,) the Upper and Lower Falls of the Yellowstone, Grand Cañon by moonlight, Tower Falls, the East and North Fork Falls on Gardiner River, some more lakes, a magnificent view of foliated calcareous incrustations in a spring on the Gallatin River, and wound up by showing the "Liberty Cap," surmounted by the Stars and Stripes. The text of the lecture given in a singularly fascinating way, was full of quiet humor and often eloquent. At the conclusion of the unequaled show, the lecturer was rewarded by unbounded applause.

Tuesday witnessed the closing exercises of the Association.

In Section A., Prof. Nipher, of Washington University, read the following paper on

RAIN MEASUREMENTS ON THE ROOFS OF BUILDINGS.

Somewhat over a century ago, the theory gained currency that a considerable portion of the rain which falls upon the surface of the earth was condensed from the lower strata of the atmosphere, within 100 or 200 feet of the ground, and did not fall from the clouds as one might naturally suppose. This idea grew out of the observed fact that rain-gauges placed at different elevations above the ground showed a less rainfall as the gauges were placed at higher elevations.

Howard, Dr. Frail and others, suggested that this apparent decrease in rainfall for higher elevations was caused by wind; and, in 1861, Prof. Jevons proved that condensation in the lower strata, is, in all possible cases, inappreciable, and pointed out with clearness the action of the wind in robbing the elevated gauges of their rain. His explanation is, briefly, that any obstacle placed in a stream of air causes the air to sweep over the top and around the sides of the obstacle with an increased velocity. As a result the drops which but for this disturbance in the air current would fall into the gauge are deflected from their paths, and no longer fall parallel to the general direction of the paths in the undisturbed stream. The drops evidently drift to the leeward. This explanation gives the key to the solution of the experimental results of Symmonds, who found that cylindrical gauges gave the most uniform results, and that gauges of a less diameter than two and three-quarter inches gave too small a result when placed at the elevation of one foot.

The conclusions which Jevons draws are that observations by rain gauges elevated and exposed to the wind must be rejected as worse than useless.

Nine years later (1870), the Rain Committee of the British Association made

a report at the Liverpool meeting. The results of their experiments confirmed the explanation of Jevons. It was found that the maximum of rainfall was obtained when the mouth of the gauge was placed at the surface of the ground, in summer, and 2½ to 3 inches below the surface in winter. These gauges were placed in a pit in order to prevent splashing. It was also found that the variation of the indications of the gauge was most rapid near the ground and the loss was greatest during the winter months. Unfortunately, the Committee has not been sufficiently explicit in stating to what extent the gauge was exposed to the wind, or whether it was shielded by houses in the vicinity.

In his paper in 1861 (Phil. Mag.), Jevons suggested a form of gauge that he believed to be the "most unexceptionable," as follows: "The most unexceptionable rain gauge would consist of a sheet of metal many feet square (for instance ten feet), spread flat upon the ground in an open place, with a flat collecting vessel in the center, connected by a pipe with a sunken reservoir or recording apparatus. The edges of the vessel should not be higher than an inch, so as to present no appreciable obstacle or hollow space to the wind. At the same time nothing could be lost by splashing, for the splashes within and without the vessel would be equal."

It is to be remarked here that at many important observatories it is impossible to get a ground exposure of any kind, and in such cases this form of gauge would be of little service. A more vital objection is that is not probable that the splashing into and out of the collecting vessel will be equal. In general, and particularly for violent rains, an accumulation of water in the collecting vessel would bring about a very different result.

It probably occured simultaneously to my colleague, Prof. Woodward, and myself, that this difficulty would be completely met by covering Prof. Jevons' metal sheet with square cells of equal size, each drained by equal openings at the bottom, those near the center alone being used as collectors, the others being used only to secure uniformity of splashing. This gauge seems to me to be practically perfect.

Such a gauge can not be used very generally for rain measurements, but for purposes of comparison with the more generally used, and certainly less accurate forms, it is of great value. Thus far we have been unable to find a proper exposure in St. Louis. It is hoped that this will be accomplished during the coming year.

In the meantime it is hoped that some more favorably situated person will also make a similar comparison.

After some consideration it occurred to me that by shielding the gauge from the wind by means of some device which would deflect the wind downwards, instead of allowing it to sweep up over the mouth of the gauge, the conditions of the "pit gauge" of the British Association Committee might be realized. After many unsuccessful attempts, the shield which you see before you was hit upon, which has proved perfectly successful.

The gauge is a cylinder 7.08 centimeters in diameter and about eighteen

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inches long. Six inches from what is to be the lower end of the gauge, a false bottom is made, and the cylinder is set over a turned post set into the ground. Around this gauge is placed a trumpet-shaped shield, with the mouth, or flaring part up. The shield is furnished with a clamp-screw at the bottom, and is braced near the top by metal strips reaching from the shield to a sliding collar which encircles the gauge. By this means the shield can be set at any desired altitude.

Two gauges were set at an altitude of six feet above the ground, the one shielded, the elevation of the shield being zero above the top of the gauge. The other gauge is unshielded. According to the investigations of the B. A. Committee, gauges of this elevation should indicate a rainfall 92 per cent. of that given by the "pit gauge." The unshielded gauge has, during the last summer, shown a rainfall of 97 per cent. of that given by the shield gauge. This excess by the shield gauge is plainly showed at every rain. The fact that the difference between the gauges is less than that found by the B. A. Committee, using the "pit-gauge" is easily explained. Both of our gauges are partly protected from the wind by adjacent houses and lattice-work fences. In fact, they are so well shielded that I had expected to find little, if any, difference between the two. I shall take pleasure in showing them to any member who may take interest in the matter.

The English meteorologists lay much stress upon the elevation of rain gauges, maintaining that gauges are not really comparable unless they have equal elevation above ground. It seems clear to myself, at least, their exposure to wind is an equally important factor, and I feel sure that the so-called correction due to elevation, may be reduced to zero, by properly shielding the gauge from the winds, and that the gauges may then have any desirable or convenient location.

This conclusion has been severely tested during the past summer, by gauges placed upon and above the roof of the Central Tower of the University building.

The experiment soon convinced me that no gauge placed directly on the roof could give the true rainfall, except by accident, or under very special circumstances. These circumstances are, that the roof shall be square and flat, or nearly so, and of large size, the gauge being placed in the center of the roof. These conditions have fortunately been realized in the gauge of Dr. Geo. Engelmann, of this city. A balustrade also surrounds his gauge, which is also an important advantage. Being unable to secure such an exposure on the roof of the University building, the gauge was finally raised to an elevation of eighteen feet above the roof, and one hundred and eighteen feet above the ground. It was found that the unshielded gauge, compared with the ground gauge, showed a loss of 18 to 20 per cent.

The shield was placed around the gauge, and clamped with its rim at various elevations above the top of the gauge. It appears that at an elevation of three and a half inches the shielded gauges on the ground and on the roof will bear like relations to the unshielded ground gauge. When placed at this elevation the wind appears to have little effect upon the amount of water caught. Even when at other elevations the true ground rainfall has been shown during calms, as can

be seen in the table above, and as was also found in the guages placed upon the roof. The results appear, then, to show that the results obtained by the "pit gauge" of the B. A. committee can be realized by a properly shielded gauge placed at any convenient elevation, and which, therefore, meets the serious objections urged against the general use of the "pit gauge."

The following papers were also read:

On the Possibility of observing the Solar Corona without the aid of an eclipse, Ormond Stone; On a modified form of Telephone intended for a Sensitive Electroscope for the Detection of Feeble Currents, P. H. Vander Weyde; A Peculiar Case of Fracture of Tool Steel, Wm. Kent; Internal Revenue Adjustment of the Carlisle Tables, E. B. Elliott; International Coinage—its progress, E. B. Elliott; The Rainfall of the Arid Region of the United States, J. W. Powell.

A paper was read by Mr. E B. Elliott, of Washington, D. C., entitled,

THE INTERNAL REVENUE ADJUSTMENT OF THE CARLISLE TABLES.

The Internal Revenue Bureau, many years ago, adopted as the basis of its computations in the assessment of taxes on legacies, distributive shares and successions, the "Carlisle Tables," and 6 per cent as the rate of interest.

These tables represented very fairly the class of lives interested in legacies in succession, but were in certain respects faulty. The data from which they were computed were comparatively small, the entire number of deaths being less than 2,000. Owing to this paucity of data, irregularities necessarily resulted, and the mortality at certain older ages was represented as being less than at the younger ages immediately preceding. This was notably the case at certain very advanced years of life. For instance, the present value of a dollar due at death was made for each of the six years of age, from age ninety-two to age ninety-seven, inclusive, to be smaller than for either of the ages immediately preceding, the average of value for these six years being .80,523, while the value for the age ninety was .81,513, and for the age ninety-one, .81.615; that is to say, while the present value of a revisionary payment of one hundred dollars due at death of a person aged ninety and ninety-one is about $81.50, the value of such reversion for the following six years averaged $80.50. These extreme irregularities had not produced very great inconvenience in practice, they being found chiefly at the more advanced ages, where there were but few actual transactions. In the publication, however, of the new instructions to Internal Revenue Assessors, as to the levying of taxes on life and revisionary interests in heritable property, it was deemed advisable by the office to secure such an adjustment of these valuable tables as, without widely departing from the general character of the results, would remove these irregularities. Mr. Elliott was accordingly requested to prepare such adjustment, and the tables so adjusted were presented to the Associa-

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tion, with an explanation of the mathematical process by which the results were obtained. In the tables furnished future duration, or "expectation of life," so called, was not given, it being of no practical use in the assessment of taxes. A column entitled "redemption period" is given, it denoting a period of years in which the present values of annuities and reversions certain will become equivalent, respectively, if computed at an interest of 6 per cent per annum, to the present values of annuities and reversions contingent on the duration of life. Mr. Elliott expressed regret that we had no national system for the registry of deaths, although in certain states such systems were established, and he moreover expressed the hope that Congress would take early steps to bring about such a coöperation between the National Government and the governments of the several states as would result in an efficient and uniform system for the registry of births and deaths.

Mr. Elliott then read a paper on "International Coinage—Its Progress." He stated the condition of the monetary question in the United States and abroad a year ago as presented at the Nashville meeting of the Association, and mentioned the changes which had taken place since then. He also gave a full explanation of the difficulty which seems of late to have arisen in relation to the trade dollar.

BIOLOGICAL NOTES ON THE GALL-MAKING PEMPHIGINÆ.

BY PROF. CHARLES V. RILEY.

(*Abstract.*)

The life-history and aganic multiplication of the plant-lice (*Aphididæ*) have always excited the interest of entomologists and even of anatomists and embryologists. The life-history, however, of the gall-making species belonging to the *Pemphiginæ* has baffled the skill of observers more than that of any other group.

Prof. Riley is about to publish some new biological discoveries relating to this family of insects, in connection with a descriptive and monographic paper by Mr J. Monell, of the St. Louis Botanic Gardens. The paper laid before the Association simply records some of the yet unpublished facts discovered.

All of the older writers in treating of the different gall-producing *Pemphiginæ* of Europe have invariably failed to trace the life-history of the different species after the winged females leave the galls, and, with few exceptions, have erroneously inferred that the direct issue from the winged females hibernates somewhere. The most recent production on the subject is a paper published the present year in Cassel, Germany, by Dr. H. F. Kessler, entitled the "Life-History of the Gall-Making Plant-Lice, affecting *Ulmus Campestris*." The author, by a series of ingenious experiments, rightly came to the conclusion that the insects hibernate on the trunk, but he failed to discover in what condition they so hibernate.

Led by his previous investigations into the habits of the Grape *Phylloxera*, Prof. Riley discovered, in 1875, that some of our elm-feeding species of *Pem-*

phiginæ produce wingless and mouthless males and females, and that the female lays but one solitary impregnated egg. Continuing his observations, especially during the present summer, he has been able to trace the life-history of those species producing galls on our own elms, and to show that they all agree in this respect, and that the impregnated egg produced by the female is consigned to the sheltered portions of the trunk of the tree and there hibernates—the issue therefrom being the stem-mother which founds the gall-inhabiting colony the ensuing spring.

Thus the analogy in the life-history of the *Pemphiginæ* and the *Phylloxerinæ* is established, and the question as to what becomes of the winged insects after they leave the galls is no longer an open one. They instinctively seek the bark of the tree and there give birth to the sexual individuals, either directly, or in one species through intervening generations.

The section then adjourned.

SECTION B.

The following papers were read in Section B: On the Consensus in animal and vegetable life, Lester F. Ward; Notice of a recent discovery of gold in the Unaka Mountains of Tennessee, James H. Safford; Notice of certain sulphide springs in Tennessee, James M. Safford; An atlas of North American antiquities, O. T. Mason; North American Indian synonymy, O. T. Mason; On *Ægeria tipuliformis* Lin. Geo. H. Perkins; Osteology of *Sciuroptreus volucella*, Geo. H. Perkins.

We have now given as full a report of the proceedings as our space will permit, and close it by giving a list of the newly elected officers and of the total number of papers filed with the Secretary.

Many other papers were read before the sections and sub-sections which we should be glad to publish, but cannot for the reason given above, and for the additional reason in some cases that we have not been furnished with copies or abstracts of them.

We will conclude Prof. Newcomb's most admirable and comprehensive address in our next issue; also several other interesting papers that have been furnished by their authors.

The number of old members present was one hundred and thirty-three, and of new ones elected, two hundred and sixteen; fellows elected, sixteen.

The people of St. Louis were particularly attentive to the members, and endeavored to make their visit pleasant and interesting, by a banquet at the Lindell Hotel, concerts, excursions to Iron Mountains under the leadership of Prof. Broadhead, the Cahokia Mounds, the Waterworks, Shaw's Garden, the Silver Reduction Works at Cheltenham, the Artificial Ice Factory, &c., besides which the Mercantile Library, Prof. Shumard's magnificent collection of minerals and fossils and various other collections of interest, were freely thrown open to them, all of which courtesies were duly acknowledged officially.

XUM

On Tuesday evening at 8 o'clock the Association adjourned to meet at Saratoga, N. Y., the last Wednesday in August.

OFFICERS ELECTED FOR 1879.

President, Geo. F. Barker, of Philadelphia, ; Vice-President Section A, Prof. S. P. Langley, of Alleghany; Vice-President Section B, Maj. J. W. Powell, of Washington; Chairman of Subsection of Chemistry, Prof. Ira Remsen, of Baltimore; Chairman of Subsection of Microscopy, Prof. Edw. W. Morley, of Hudson, O.; Permanent Secretary, F. W. Putnam, of Cambridge; General Secretary, Dr. Geo. Little, of Atlanta; Secretary of Section A, Prof. John K. Rees, of St. Louis; Secretary of Sec ion B, Prof. A. G. Wetherby, of Cincinnati; Treasurer, Wm. S. Vaux, of Philadelphia; Auditing Committee, Dr. Henry Wheatland, of Salem; Thomas Meehan, of Philadelphia.

TITLES OF PAPERS FILED FOR THE ST. LOUIS MEETING.

On the Sources of Aboriginal History of Spanish America, Ad. F. Bandalier.

Experimental Determination of the Velocity of Light, Albert A. Michelson.

The Gold Gravel of North Carolina, its age and mode of formation, and the history of its discovery and working, W. C. Kerr.

Dominant Forms of Topography of North Carolina in Mountain and Plain and their geological explanation, W. C. Kerr.

Sand Dunes on the Coast of North Carolina and their geological and topographical significance, W. C. Kerr.

Ancient Mounds in the Vicinity of Naples, Scott county, Illinois, J. G. Henderson.

Tornadoes, Waterspouts and Hailstorms, Wm. Ferrel.

The Natural Features of the Yellow Stone National Park, Wm. I. Marshall.

Ancient Glacial Action, Kelly's Island, Lake Erie, Chas. Whittlesey.

The Philosophy of the Movements of the Rocky Mountain Locust (*Caloptenus spretus*), Chas. V. Riley.

A New Source of Wealth to the United States, Chas. V. Riley.

Notes on the life-history of the Blister-beetles, and on the structure and development of the genus *Hornia* Riley, Chas. V. Riley.

On the larval growth of *Corydalus Chauliodes*, Chas. V. Riley.

On the Means by which Silkworm moths issue from their cocoons, Chas V. Riley.

On Hybrids in Nature, Thos. Meehan.

Remarks on the Early Decay of the male plant in *Cannabis sativa*: A Parallel and a Contrast, C. S. Percival.

A Wind-vane thoroughly Sensitive and thoroughly Steady, Wm. Curtis Taylor.

An improved Method of Ringing a Bell in an Exhausted Receiver, Thos. R. Baker.

Immortality, W. H. H. Russell.

The Science of Government, W. H. H. Russell.

The Iron Ores of Alabama, with Special Reference to their Geological Relations, Eugene A. Smith.

Ancient Names, Geographical, Tribal and Personal, in the Mississippi Valley, J. G. Henderson.

The Electrolytic Estimation of Mercury, F. W. Clarke.

Embryology of Clepsine (1) Stages preliminary to Cleavage (2) Cleavage, Germ-lamellæ, Gastrula, etc., C. O. Whitman.

Description of Two Stone Cists discovered near Highland, Ill., Arthur Oehler.

Description of a Cliff House in the Cañon of Mancos River, Colorado, with a Ground Plan of the structure. Wm. F. Morgan.

Remarks on the Ruins of a Stone Pueblo on the Animas River, New Mexico, with a Ground Plan, Lewis H. Morgan.

Observations on the San Juan River District, as an important ancient seat of Village Indian Life, Lewis H. Morgan.

Magnetic Determinations in Missouri, Francis E. Nipher.

On the Determination of Rainfall on Roofs, Francis E. Nipher.

On the use of the Tasimeter for measuring the Heat of the Stars and of the Sun's Corona, Thos. A. Edison.

On Finding the Differential of a Variable Quantity without the use of Infinitesimals or "Limits," Joseph Ficklin.

On the complete series of Superficial Formations in Northwestern Iowa, with Sections, W. J. McGee.

The Law of Repetition, Miss V. K. Bowers.

The Science of Human Nature, a Philosophical View of the Law of Habit or Repetition, Miss V. K. Bowers.

The Universally Implanted, or Race Faculties and Personal Character, Miss V. K. Bowers.

Extracts from Modern Science bearing on the law of Repetition, Miss V. K. Bowers.

Richthofen's Theory of the Loess in the Light of the Deposits of the Missouri, James E. Todd.

On the Economic use of Steam, Chas. A. Smith.

Notes on Antimony Tannate, Ellen S. Richards and Alice W. Palmer.

Outline of Work done by the Fort Worth Solar Eclipse Party, J. K. Rees.

Are the so-called Chætetes of the Cincinnati Group Bryozoans? A. G. Wetherby.

Remarks on the Geographical Distribution of the Land and Fresh-water Mollusks of the United States and their local varieties, A. G. Wetherby.

A new Fossil impression in a Glacial Boulder, A. R. Grote.

Remarks upon the Archæology of Vermont, G. H. Perkins.

On Friction Measurements and its Laws, as determined by Recent Experi-

ments for a wider range of Conditions than have been previously obtained, R. H. Thurston.

Dinosaurian Reptiles from the Jurassic of the Rocky Mountains, O. C. Marsh.

Ancient Pottery from Chiriqui, Central America, O. C. Marsh.

The Relation of Adhesion to Horizontal Pressure in Mountain Dynamics, H. F. Walling.

Some indications of Recent Sensitiveness to Pressure in the Earth's Crust, H. F. Walling.

Remarkable Burial Custom from a Mound in Florida. The Cranium utilized as a Cinerary Urn, Henry Gillman.

Description of a Glazed Earthen Vessel, taken from a Tumulus in Florida, Henry Gillman.

Evidences of Cannibalism in a Nation before the Ainos in Japan, E. S. Morse.

Geological History of the Colorado River and Plateaus, C. E. Dutton.

A Peculiar Case of Fracture of Tool Steel, .William Kent.

On the Consensus in Animal and Vegetable Life, Lester F. Ward.

Some new Selenocyanates, F. W. Clarke.

Some Specific Gravity determinations and conclusions from them, F. W. Clarke.

Notice of a recent discovery of Gold in the Unaka Mountains of Tennessee, Jas. M. Safford.

Notice of Certain Sulphide Springs in Tennessee, Jas. M. Safford,

The Importance of Meteorological Observations in Vertical Sections of the Atmosphere, with the suggestion of means for their systematic accomplishment, J. W. Osborne.

On the Construction of a Sensitive Wind-vane, J. W. Osborne.

On Wind-vane Rotation, J. W. Osborne.

On the development of Ozone in the air by means of sudden changes of temperature, Benj. S. Hedrick.

An Atlas of North American Antiquities, O. T. Mason.

North American Indian Synonomy, O. T. Mason.

The Lands of Utah, J. W. Powell.

The Rainfall of the Arid Region of the United States, J. W. Powell.

On a remnant of the Spiracles in *Amia* and *Lepidosteus*, Burt G. Wilder.

On *Ægina tipuliformis* Lin., George A. Perkins.

Osteology of *Sciuropterus volucilla*, George A. Perkins.

On the Development of *Amia*, S. A. Forbes.

On the Influence of the Drainage rate on Climate, Chas. W. Johnson.

The Matter of Life, Chas. W. Johnson.

On some Characteristics of the Vegetation of Iowa, J. C. Arthur.

On the Possibility of Observing the Solar Corona without the Aid of an Eclipse, Ormond Stone.

On the Application of the Carbon Button, T. A. Edison.

On the Principle involved in the Microphone and the Carbon Telephone, T. A. Edison.

A new Voltameter, T. A. Edison.

On the Results of the Spectroscopic Observation of the Solar Eclipse of July 29, 1878, G. F. Barker.

A new Method of Determining the Pitch of a Tuning Fork, G. A. Barker.

On certain Difficulties met with in Using the Cat's Brain as a Type of the Brains of Mammals, Burt G. Wilder.

On the Anatomical peculiarities by which Mound Builders' Crania may be distinguished from those of the Modern Indian, M. J. Mc Gee.

Electricity an Agent in Vegetable Growth, A. P. S. Stuart.

On a modified form of Telephone, intended for a sensitive Electroscope for the Detection of Feeble Currents, P. H. Van der Weyde.

Exhibition of Fossils, showing the Effects of the Geodizing Process, A. H. Worthen.

A Short Account of the Nature of Oxide of the New Element Mosandrum, J. Lawrence Smith.

The new Meteoric Mineral, Daubreelite, and its frequent Occurrence in Nature in Meteoric Iron, J. Lawrence Smith.

On recent progress in Microscopy, R. H. Ward.

On a Standard Inch and a Standard Centimetre, Wm. A. Rogers.

The Aerion; its theories, illustrations and references, Ira H. Stone.

Exhibition of Prehistoric Relics from Missouri, A. J. Conant.

An account of an exploration of a Walled Town of the Moundbuilders of the Cumberland Valley, F. W. Putnam.

On Improvements in Electric Clock Systems, F. E. Nipher.

On the Compass Plants, George Engelman.

On the Discovery of a Human Skull in the Drift, near Denver, Colorado, Thomas Belt.

Discovery of Atlantosaurus and other Dinosaurs in the Rocky Mountains of Colorado, A. Lakes.

International Coinage, E. B. Elliott.

Internal Revenue Adjustment of the Carlisle Tables, E. B. Elliott.

Biological Notes on the Gall-making Pemphiginæ, C. V. Riley.

The Alleged Volcano at Bald Mt., North Carolina, F. W. Clarke.

On an error in estimating the strength of a steam boiler, Samuel Marsden.

The Gold Regions of Georgia, George Little.

PREHISTORIC RUINS.

Back of the lost Aztec cities there are in this region of country not merely traces but very well-preserved ruins of the dwellings of a people who lived so long ago that not history or tradition, or even a legend, has kept even so much

as the shadow of their memory. Prof. Tucker, of Hayden's United States Survey, has made quite a study of their remains, and has given some interesting details concerning their discovery.

At first the distance of these cave dwellings was unknown to the party, but one of them, sharper-eyed than the others, suddenly descried way up near the top of the bluff, fully a thousand feet from their base, perfect little houses sandwiched in among the crevices of the horizontal strata of the rock of which the bluffs were composed.

At the peril of his life one of the party scaled the precipice, and letting himself down into one of the houses, found the masonry as firm and solid as when first constructed, and so smooth and even that the casual observer from the cañon below would not notice the difference between it and the rock itself once in fifty times passing.

The Cliff House in the Mancos was one of the wonders of their discoveries, it being first seen one evening just as the sun was sinking behind the western walls of the cañon. Perched in its little nook, like a swallow's nest, the Cliff House was found to be two stories in height, and evidently an edifice of considerable distinction, as its upper windows command an extended view down the cañon, and its position generally that of pre-eminence over the entire section thereabouts. The interior was found to be arranged far more elaborately than in any other building yet explored, the windows incased in wood, neatly fashioned, the sills and lintels still showing evidences of having been stained in imitation of dark woods, and most of it in a remarkably fair state of preservation. Some distance from the building, and upon other ledges, the ruins of quite a number of smaller buildings were found, and all of them ranging from seven hundred to one thousand feet from the bottom of the cañon below. Many readers will recall the models of these cliff houses, which were on view at the Centennial Exhibition, in the Government department, and which were always the center of a fascinated throng of the most intelligent and cultivated visitors.

BOOK NOTICES.

THROUGH THE DARK CONTINENT, by Henry M. Stanley. Two volumes in one: pp. 985, octavo, with maps and illustrations. Toronto, John B. Magurn, 1878. For sale by M. H. Dickinson, successor to Matt. Foster & Co. Price, cloth, $5.50; leather, library style, $6.50.

This is a Canadian book, printed from *fac simile* plates with the English and American editions and sold at about half the price. It is hardly necessary to say anything further about it, as every intelligent reader in this portion of the West knows all about "Stanley Africanus," and will be in haste to procure an early copy of this his most important work. We will, however, say that this volume is printed and bound in a handsome style, and the illustrations, numbering one hundred and forty-nine, and the ten maps, are executed in the best and most artistic manner, so that it will prove a source of pleasure to the reader, aside from the interest attaching to the subject matter, which, of course, is intensely fascinating. No book of the present day has been so impatiently waited for, and none is more likely to gratify the expectations of those so waiting.

M. H. Dickinson is the sole agent for this region and will send it to any address upon receipt of price.